This file documents the installation and use of the programs in Web2c, an implementation of Donald Knuth’s TeX system.


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1 Introduction

This manual corresponds to version 2020 of Web2c, released in March 2020.

Web2c is the name of a T\TeX{} implementation, originally for Unix, but now also running under DOS, Amiga, and other operating systems. By T\TeX{} implementation, we mean all of the standard programs developed by the Stanford T\TeX{} project directed by Donald E. Knuth: Metafont, DVItype, GFtoDVI, BibT\TeX{}, Tangle, etc., as well as T\TeX{} itself. Other programs are also included: DVIcopy, written by Peter Breitenlohner, MetaPost and its utilities (derived from Metafont), by John Hobby, etc.

General strategy: Web2c works, as its name implies, by translating the WEB source in which T\TeX{} is written into C source code. Its output is not self-contained, however; it makes extensive use of many macros and functions in a library (the web2c/lib directory in the sources). Therefore, it will not work without change on an arbitrary WEB program.

Availability: All of Web2c is freely available—“free” both in the sense of no cost (free ice cream) and of having the source code to modify and/or redistribute (free speech). See Section “unixtex.ftp” in Kpathsea, for the practical details of how to obtain Web2c.

Different parts of the Web2c distribution have different licensing terms, however, reflecting the different circumstances of their creation; consult each source file for exact details. The main practical implication for redistributors of Web2c is that the executables are covered by the GNU General Public License, and therefore anyone who gets a binary distribution must also get the sources, as explained by the terms of the GPL (see Section “Copying” in Kpathsea). The GPL covers the Web2c executables, including tex, because the Free Software Foundation sponsored the initial development of the Kpathsea library that Web2c uses. The basic source files from Stanford, however, have their own copyright terms or are in the public domain, and are not covered by the GPL.

History: Tomas Rokicki originated the T\TeX{}-to-C system in 1987, working from the first change files for T\TeX{} under Unix, which were done primarily by Howard Trickey and Pavel Curtis. Tim Morgan then took over development and maintenance for a number of years; the name changed to Web-to-C somewhere in there. In 1990, Karl Berry became the maintainer. He made many changes to the original sources, and started using the shorter name Web2c. In 1997, Olaf Weber took over. Dozens of other people have contributed; their names are listed in the ChangeLog files.

Other acknowledgements: The University of Massachusetts at Boston (particularly Rick Martin and Bob Morris) provided computers and ftp access to me for many years. Richard Stallman at the Free Software Foundation employed me while I wrote the original path searching library (for the GNU font utilities). (rms also gave us Emacs, GDB, and GCC, without which I cannot imagine developing Web2c.) And, of course, T\TeX{} would not exist in the first place without Donald E. Knuth.

Further reading: See Appendix B [References], page 54.
2 Installation

(A copy of this chapter is in the distribution file web2c/INSTALL.)

Installing Web2c is mostly the same as installing any other Kpathsea-using program. Therefore, for the basic steps involved, see Section “Installation” in Kpathsea. (A copy is in the file kpathsea/INSTALL.)

One peculiarity to Web2c is that the source distribution comes in two files: web.tar.gz and web2c.tar.gz. You must retrieve and unpack them both. (We have two because the former archive contains the very large and seldom-changing original WEB source files.) See Section “unixtex.ftp” in Kpathsea.

Another peculiarity is the MetaPost program. Although it has been installed previously as mp, as of Web2c 7.0 the installed name is now mpost, to avoid conflict with the mp program that does prettyprinting. This approach was recommended by the MetaPost author, John Hobby. If you as the T\TeX administrator wish to make it available under its shorter name as well, you will have to set up a link or some such yourself. And of course individual users can do the same.

For solutions to common installation problems and information on how to report a bug, see the file kpathsea/BUGS (see Section “Bugs” in Kpathsea). See also the Web2c home page, http://www.tug.org/web2c.

Points worth repeating:

- Before starting the standard compilation and installation you must install the basic fonts, macros, and other library files. See Section “Installation” in Kpathsea.
- If you do not wish to use the standard file locations, see Section “Changing search paths” in Kpathsea.
- Some Web2c features are enabled or disabled at configure time, as described in the first section below.

2.1 configure options

This section gives pointers to descriptions of the ‘--with’ and ‘--enable’ configure arguments that Web2c accepts. Some are specific to Web2c, others are generic to all Kpathsea-using programs.

For a list of all the options configure accepts, run ‘configure --help’. The generic options are listed first, and the package-specific options come last.

For a description of the generic options (which mainly allow you to specify installation directories) and basic configure usage, see Section “Running configure scripts” in Autoconf, a copy is in the file kpathsea/CONFIGURE.

‘--disable-dump-share’
Do not make fmt/base/mem files sharable across different endian architectures. See Section 3.5.2.3 [Hardware and memory dumps], page 11.
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'--without-maketexmf-default'
'--without-maketexpk-default'
'--without-maketextfm-default'
'--with-maketextex-default'

Enable or disable the dynamic generation programs. See Section “mktex configuration” in Kpathsea. The defaults are the inverse of the options, i.e., everything is enabled except mktexmf.

'--enable-shared'

Build Kpathsea as a shared library. See Section “Shared library” in Kpathsea.

'--with-editor=cmd'

Change the default editor invoked by the ‘e’ interactive command. See Section 3.5.3 [Editor invocation], page 12.

'--with-epsfwin'
'--with-hp2627win'
'--with-mftalkwin'
'--with-nextwin'
'--with-regiswin'
'--with-suntoolswin'
'--with-tektronixwin'
'--with-unitermwin'
'--with-x'
'--with-x-toolkit=KIT'
'--with-x11win'
'--with-x11'

Define Metafont graphics support; by default, no graphics support is enabled. See Section 5.4 [Online Metafont graphics], page 28.

'--x-includes=dir'
'--x-libraries=dir'

Define the locations of the X11 include files and libraries; by default, configure does its best to guess). See Section “Optional Features” in Autoconf. A copy is in kpathsea/CONFIGURE.

2.2 Compile-time options

In addition to the configure options listed in the previous section, there are a few things that can be affected at compile-time with C definitions, rather than with configure. Using any of these is unusual.

To specify extra compiler flags ('-Dname' in this case), the simplest thing to do is:

make XCFLAGS="ccoptions"

You can also set the CFLAGS environment variable before running configure. See Section “configure environment” in Kpathsea.

Anyway, here are the possibilities:
Chapter 2: Installation

'DFIXPT'
'DNO_MF_ASM'

Use the original WEB fixed-point routines for Metafont and MetaPost arithmetic calculations regarding fractions. By default, assembly-language routines are used on x86 hardware with GNU C (unless 'NO_MF_ASM' is defined), and floating-point routines are used otherwise.

'DIPC_DEBUG'

Report on various interprocess communication activities. See Section 4.6 [IPC and \TeX{}], page 23.

2.3 Additional targets

Web2c has several Make targets besides the standard ones. You can invoke these either in the top level directory of the source distribution (the one containing kpathsea/ and \texttt{web2c/}), or in the \texttt{web2c/} directory.

'c-sources'

Make only the C files, translated from the Web sources, presumably because you want to take them to a non-Unix machine.

'formats'
'install-formats'

Make or install all the memory dumps (see Section 3.5.2 [Memory dumps], page 10). By default, the standard plain formats plus \texttt{latex.fmt} are made. You can add other formats by redefining the \texttt{fmts}, \texttt{bases}, and \texttt{mems} variables. See the top of \texttt{web2c/Makefile} for the possibilities.

'fmts'
'install-fmts'

Make or install the \LaTeX{} .fmt files. See Section 4.2 [Initial TeX], page 17.

'bases'
'install-bases'

Make or install the Metafont .base files. See Section 5.2 [Initial Metafont], page 26.

'mems'
'install-mems'

Make or install the MetaPost .mem files. See Section 6.2 [Initial MetaPost], page 34.

'triptrap'
'trip'
'trap'
'mptrap' To run the torture tests for \LaTeX{}, Metafont, and MetaPost (respectively). See the next section.

2.4 Trip, trap, and mptrap: Torture tests

To validate your \LaTeX{}, Metafont, and MetaPost executables, run \texttt{make triptrap}. This runs the trip, trap, and mptrap “torture tests”. See the files \texttt{triptrap/tripman.tex},
triptrap/trapman.tex, and triptrap/mptrap.readme for detailed information and background on the tests.

The differences between your executables’ behavior and the standard values will show up on your terminal. The usual differences (these are all acceptable) are:

- string usage and table sizes;
- glue set ratios;
- ‘\down4’, ‘\right4’, and ‘\y4’ commands in DVItype output;
- dates and times.

Any other differences are trouble. The most common culprit in the past has been compiler bugs, especially when optimizing. See Section “\TeX or Metafont failing” in Kpathsea.

The files trip.diff, mftrap.diff, and mptrap.diff in the triptrap directory show the standard diffs against the original output. If you diff your diffs against these files, you should come up clean. For example

```bash
make trip >&mytrip.diff
diff triptrap/trip.diff mytrip.diff
```

To run the tests separately, use the targets trip, trap, and mptrap.

To run simple tests for all the programs as well as the torture tests, run ‘make check’. You can compare the output to the distributed file tests/check.log if you like.

### 2.5 Runtime options

Besides the configure- and compile-time options described in the previous sections, you can control a number of parameters (in particular, array sizes) in the \texttt{texmf.cnf} runtime file read by Kpathsea (see Section “Config files” in Kpathsea).

Rather than exhaustively listing them here, please see the last section of the distributed kpathsea/texmf.cnf. Some of the more interesting values:

- **‘main_memory’**
  Total words of memory available, for \TeX, Metafont, and MetaPost. Must remake the format file after changing.

- **‘extra_mem_bot’**
  Extra space for “large” \TeX data structures: boxes, glue, breakpoints, et al. If you use PiCT\TeX, you may well want to set this.

- **‘font_mem_size’**
  Words of font info available for \TeX; this is approximately the total size of all TFM files read.

- **‘hash_extra’**
  Additional space for the hash table of control sequence names. Approximately 10,000 control sequences can be stored in the main hash table; if you have a large book with numerous cross-references, this might not be enough, and thus you will want to set hash_extra.

Of course, ideally all arrays would be dynamically expanded as necessary, so the only limiting factor would be the amount of swap space available. Unfortunately, implementing
this is extremely difficult, as the fixed size of arrays is assumed in many places throughout the source code. These runtime limits are a practical compromise between the compile-time limits in previous versions, and truly dynamic arrays. (On the other hand, the Web2c Bib\TeX implementation does do dynamic reallocation of some arrays.)
3 Commonalities

Many aspects of the TeX system are the same among more than one program, so we describe all those pieces together, here.

3.1 Option conventions

To provide a clean and consistent behavior, we chose to have all these programs use the GNU function \texttt{getopt_long_only} to parse command lines. However, we do use in a restricted mode, where all the options have to come before the rest of the arguments.

As a result, you can:

\begin{itemize}
  \item use ‘-’ or ‘--’ to start an option name;
  \item use any unambiguous abbreviation for an option name;
  \item separate option names and values with either ‘=’ or one or more spaces;
  \item use filenames that would otherwise look like options by putting them after an option ‘--’.
\end{itemize}

By convention, non-option arguments, if specified, generally define the name of an input file, as documented for each program.

If a particular option with a value is given more than once, it is the last value that counts.

For example, the following command line specifies the options ‘foo’, ‘bar’, and ‘verbose’; gives the value ‘baz’ to the ‘abc’ option, and the value ‘xyz’ to the ‘quux’ option; and specifies the filename ‘-myfile-’.

\begin{verbatim}
 -foo --bar -verb -abc=baz -quux karl --quux xyz -- -myfile-
\end{verbatim}

3.2 Common options

All of these programs accept the standard GNU ‘--help’ and ‘--version’ options, and several programs accept ‘--verbose’. Rather than writing identical descriptions for every program, they are described here.

‘--help’ Print a usage message listing basic usage and all available options to standard output, then exit successfully.

‘--verbose’ Print progress reports to standard output.

‘--version’ Print the version number to standard output, then exit successfully.

\TeX, Metafont, and MetaPost have a number of additional options in common:

‘-file-line-error’

‘-no-file-line-error’

Change (or do not change) the way error messages are printed. The alternate style looks like error messages from many compilers and is easier to parse for some editors that invoke \TeX. This option used to be called ‘-file-line-error-style’.
'fmt=\textit{dumpname}'
'base=\textit{dumpname}'
'mem=\textit{dumpname}'

Use \textit{dumpname} instead of the program name or a ‘\%\&’ line to determine the name of the memory dump file read (‘fmt’ for \LaTeX, ‘base’ for Metafont, ‘mem’ for MetaPost). See Section 3.5.2 [Memory dumps], page 10. Also sets the program name to \textit{dumpname} if no ‘-progsname’ option was given.

'\texttt{-halt-on-error}'
Stop processing and exit when an error occurs, as opposed to the normal process of trying to recover and continue.

'\texttt{-ini}'
Enable the “initial” form of the program (see Section 3.5.1 [Initial and virgin], page 10). This is implicitly set if the program name is \texttt{initex} resp. \texttt{initmf}.

'\texttt{-interaction=\textit{string}}'
Set the interaction mode from the command line. The \textit{string} must be one of ‘batchmode’, ‘nonstopmode’, ‘scrollmode’, or ‘errorstopmode’.

'\texttt{-jobname=\textit{string}}'
Set the job name to \textit{string}, instead of deriving it from the name of the input file.

'\texttt{-kpathsea-debug=\textit{number}}'
Set path searching debugging flags according to the bits of \textit{number} (see Section “Debugging” in Kpathsea). You can also specify this in \texttt{KPATHSEA_DEBUG} environment variable (for all Web2c programs). (The command line value overrides.) The most useful value is ‘-1’, to get all available output.

'\texttt{-output-directory=\textit{dirname}}'
Specify the directory \textit{dirname} to which output files are written. Also look for input files in \textit{dirname} first, before looking along the normal search path. See Section 3.4 [Output file location], page 9.

'\texttt{-parse-first-line}'
'\texttt{-no-parse-first-line}'
Check or disable checking whether the first line of the main input file starts with ‘\%\&’, and parse it if it does. This line can be used specify the format and/or a TCX file.

'\texttt{-progsname=\textit{string}}'
Set program (and memory dump) name to \textit{string}. This may affect the search paths and other values used (see Section “Config files” in Kpathsea). Using this option is equivalent to making a link named \textit{string} to the binary and then invoking the binary under that name. See Section 3.5.2 [Memory dumps], page 10.

'\texttt{-recorder}'
Enable the filename recorder. This makes the program save a list of the opened files into a file with (by default) extension ‘.fls’. For Aleph, this option is always on, and the file has extension ‘.ofl’.
Ordinarily, the `.fls' file is written to the same location as the `.log' file, for example, respecting `-output-directory' if it is given (see Section 3.4 [Output file location], page 9). However, if \TeX\ processing is done on the command line (or in response to the `**' prompt), the `.fls' might be written to the current directory, or include an integer (the current pid), as in `texput1234.fls'. You can use `-jobname' to explicitly set the basename.

`-translate-file=tcxfile'

Use `tcxfile' to define which characters are printable and translations between the internal and external character sets. Moreover, `tcxfile' can be explicitly declared in the first line of the main input file `\& -translate-file=tcxfile'. This is the recommended method for portability reasons. See Section 4.4.2 [TCX files], page 20.

`-8bit'

This option specifies that by default all characters should be considered printable. If `-translate-file' was given as well, then the TCX file may mark characters as non-printable.

### 3.3 Path searching

All of the Web2c programs, including \TeX, which do path searching use the Kpathsea routines to do so. The precise names of the environment and configuration file variables which get searched for particular file formatted are therefore documented in the Kpathsea manual (see Section “Supported file formats” in Kpathsea). Reading `texmf.cnf' (see Section “Config files” in Kpathsea), invoking `mktex... scripts' (see Section “mktex scripts” in Kpathsea), and so on are all handled by Kpathsea.

The programs which read fonts make use of another Kpathsea feature: `texfonts.map', which allows arbitrary aliases for the actual names of font files; for example, `Times-Roman' for `ptmr8r.tfm'. The distributed (and installed by default) `texfonts.map' includes aliases for many widely available PostScript fonts by their PostScript names.

### 3.4 Output file location

All the programs generally follow the usual convention for output files. Namely, they are placed in the directory current when the program is run, regardless of any input file location; or, in a few cases, output is to standard output.

For example, if you run `tex /tmp/foo', for example, the output will be in `./foo.dvi' and `./foo.log', not `/tmp/foo.dvi' and `/tmp/foo.log'.

You can use the `-output-directory' option to cause all output files that would normally be written in the current directory to be written in the specified directory instead. See Section 3.2 [Common options], page 7.

If the current directory is not writable, and `-output-directory' is not specified, the main programs (\TeX, Metafont, MetaPost, and Bib\TeX) make an exception: if the config file or environment variable value `TEXMFSOUTPUT' is set (it is not by default), output files are written to the directory specified.

`TEXMFSOUTPUT' is also checked for input files, as \TeX often generates files that need to be subsequently read; for input, no suffixes (such as `.tex') are added by default and no exhaustive path searching is done, the input name is simply checked as given.
3.5 Three programs: Metafont, MetaPost, and \TeX

\TeX, Metafont, and MetaPost have a number of features in common. Besides the ones here, the common command-line options are described in the previous section. The configuration file options that let you control some array sizes and other features are described in Section 2.5 [Runtime options], page 5.

3.5.1 Initial and virgin

The \TeX{} and Metafont programs each have two main variants, called initial and virgin. MetaPost no longer makes this distinction.

The initial form is enabled if:
1. the ‘-ini’ option was specified; or
2. the program name is initex resp. inimf; or
3. the first line of the main input file is ‘%&ini’;

otherwise, the virgin form is used.

The virgin form is the one generally invoked for production use. The first thing it does is read a memory dump (see Section 3.5.2.2 [Determining the memory dump to use], page 11), and then proceeds on with the main job.

The initial form is generally used only to create memory dumps (see the next section). It starts up more slowly than the virgin form, because it must do lengthy initializations that are encapsulated in the memory dump file.

3.5.2 Memory dumps

In typical use, \TeX{} and Metafont require a large number of macros to be predefined; therefore, they support memory dump files, which can be read much more efficiently than ordinary source code.

3.5.2.1 Creating memory dumps

The programs all create memory dumps in slightly idiosyncratic (thought substantially similar) way, so we describe the details in separate sections (references below). The basic idea is to run the initial version of the program (see Section 3.5.1 [Initial and virgin], page 10), read the source file to define the macros, and then execute the \texttt{\dump} primitive.

Also, each program uses a different filename extension for its memory dumps, since although they are completely analogous they are not interchangeable (\TeX{} cannot read a Metafont memory dump, for example).

Here is a list of filename extensions with references to examples of creating memory dumps:

\TeX{} (‘.fmt’) See Section 4.2 [Initial \TeX{}], page 17.

Metafont (‘.base’) See Section 5.2 [Initial Metafont], page 26.

When making memory dumps, the programs read environment variables and configuration files for path searching and other values as usual. If you are making a new installation and have environment variables pointing to an old one, for example, you will probably run into difficulties.
3.5.2.2 Determining the memory dump to use

The virgin form (see Section 3.5.1 [Initial and virgin], page 10) of each program always reads a memory dump before processing normal source input. All three programs determine the memory dump to use in the same way:

1. If the first non-option command-line argument begins with ‘&’, the program uses the remainder of that argument as the memory dump name. For example, running ‘tex \&super’ reads super.fmt. (The backslash protects the ‘&’ against interpretation by the shell.)

2. If the ‘-fmt’ resp. ‘-base’ option is specified, its value is used.

3. If the ‘-proname’ option is specified, its value is used.

4. If the first line of the main input file (which must be specified on the command line, not in response to ‘**’) is %&dump, and dump is an existing memory dump of the appropriate type, dump is used.

The first line of the main input file can also specify which character translation file is to be used: %&-translate-file=tcxfile (see Section 4.4.2 [TCX files], page 20).

These two roles can be combined: %&dump -translate-file=tcxfile. If this is done, the name of the dump must be given first.

5. Otherwise, the program uses the program invocation name, most commonly tex resp. mf. For example, if latex is a link to tex, and the user runs ‘latex foo’, latex.fmt will be used.

3.5.2.3 Hardware and memory dumps

By default, memory dump files are generally sharable between architectures of different types: specifically, on machines of different endianness (see Section “Byte order” in GNU C Library). (This is a feature of the Web2c implementation, and is not true of all T\TeX implementations.) If you specify ‘--disable-dump-share’ to configure, however, memory dumps will be endian-dependent.

The reason to do this is speed. To achieve endian-independence, the reading of memory dumps on LittleEndian architectures, such as PC’s and DEC architectures, is somewhat slowed (all the multibyte values have to be swapped). Usually, this is not noticeable, and the advantage of being able to share memory dumps across all platforms at a site far outweighs the speed loss. But if you’re installing Web2c for use on LittleEndian machines only, perhaps on a PC being used only by you, you may wish to get maximum speed.

\TeXnically, even without ‘--disable-dump-share’, sharing of .fmt files cannot be guaranteed to work. Floating-point values are always written in native format, and hence will generally not be readable across platforms. Fortunately, \TeX uses floating point only to represent glue ratios, and all common formats (plain, \LaTeX, AMS\TeX, \ldots) do not do any glue setting at .fmt-creation time. Metafont does not use floating point in any dumped value at all.

Incidentally, different memory dump files will never compare equal byte-for-byte, because the program always dumps the current date and time. So don’t be alarmed by just a few bytes difference.

If you don’t know what endianness your machine is, and you’re curious, here is a little C program to tell you. (The configure script contains a similar program.) This is from the
Chapter 3: Commonalities


```c
main ()
{
    /* Are we little or big endian? From Harbison&Steele. */
    union
    {
        long l;
        char c[sizeof (long)];
    } u;
    u.l = 1;
    if (u.c[0] == 1)
        printf ("LittleEndian\n");
    else if (u.c[sizeof (long) - 1] == 1)
        printf ("BigEndian\n");
    else
        printf ("unknownEndian\n");
    exit (u.c[sizeof (long) - 1] == 1);
}
```

3.5.3 Editor invocation

TEX, Metafont, and MetaPost all (by default) stop and ask for user intervention at an error. If the input came from a file, and the user responds with e or E, the program invokes an editor.

Specifying ‘--with-editor=cmd’ to configure sets the default editor command string to cmd. The environment variables/configuration values TEXEDIT, MFEDIT, and MPEDIT (respectively) override this. If ‘--with-editor’ is not specified, the default is vi +%d %s on Unix, and an invocation of the TÉXworks editor on Windows. (See texmf.cnf for the precise values.)

In this string, ‘%d’ is replaced by the line number of the error, and ‘%s’ is replaced by the name of the current input file.

3.5.4 \input filenames

TEX, Metafont, and MetaPost source programs can all read other source files with the \input (TEX) and input (MF and MP) primitives:

\input name % in TeX

The file name can always be terminated with whitespace; for Metafont and MetaPost, the statement terminator ';' also works. (\input and other macro packages provide other interfaces to \input that allow different notation; here we are concerned only with the primitive operation.)

As (allowed) extensions to standard TÉX, Web2c also supports specifying the filename in double quotes ("some name") and in braces (\{"some name"\}), which is convenient for filenames containing spaces or other special characters, as described in the sections below.

In all cases, space tokens are ignored after the filename is read.
Also, double quote (") characters are ignored within the filename; there is no way to read files whose names contain a ".

However, for maximal portability of your document across systems, use only the characters ‘a’–‘z’, ‘0’–‘9’, and ‘.’. Do not use anything but simple filenames, since directory separators vary among systems; instead, add the necessary directories to the appropriate search path.

3.5.4.1 \texttt{\input quoted filename: \input "some name"}

As of Web2c version 7.5.3 (2004), double-quote characters can be used to include spaces or other special characters. In typical use, the ‘"’ characters surround the entire filename:

\input "filename with spaces"

Technically, the quote characters can be used inside the name, and can enclose any characters, as in:

\input filename" "with" "spaces"

One more point. In \TeX, the quotes are needed inside the braces of its \texttt{\input} macro, thus:

\begin{verbatim}
\input{a b} % fails
\input{"a b"} % ok
\end{verbatim}

There is no way to quote the quote character.

3.5.4.2 \texttt{\input braced filename: \input{some name}}

As of Web2c 2020, \texttt{\input} filenames in \TeX engines (this does not apply in Metafont and MetaPost) can also be specified within a \TeX group, typically curly braces. For example:

\input{filename with spaces}

As always with \TeX, the brace characters are not hardwired; what counts is the category code: the first token after the \texttt{\input} must be of catcode 1 (begin group), and it is matched with the next character of catcode 2 (end group).

Within the group-delimited filename, braces are treated as normal characters.

As with all forms of filenames, following spaces are ignored (after the end group), and double quote (") characters are ignored within the filename.

3.5.4.3 \texttt{\input filename caveats}

The quoting mechanisms just described come into play after \TeX has tokenized and expanded the input. So, multiple spaces and tabs will generally be seen as a single space, active characters such as ‘~’ are expanded first (generally causing an error), and so on. More examples below.

On the other hand, various C library routines and Unix itself use the null byte (character code zero, ASCII NUL) to terminate strings. So filenames in Web2c cannot contain nulls, even though \TeX itself does not treat NUL specially.

Finally, the present Web2c implementation does ‘~’ and ‘$’ expansion on \textit{name}, unlike Knuth’s original implementation. Thus:

\begin{verbatim}
\input ~jsmith/$foo.bar
\end{verbatim}
will dereference the environment variable or Kpathsea config file value ‘foo’ and read that file, extended with ‘.bar’, in user ‘jsmith’’s home directory. You can also use braces in the variable expansion, as in ‘${foo}bar’, if you want to follow the variable name with a letter, numeral, or ‘_’.

(So another way to get a program to read a filename containing whitespace is to define an environment variable and dereference it.)

In all the common \TeX\ formats (plain \TeX, \LaTeX, Con\TeXt, AMSTeX, . . .), the characters ‘~’ and ‘$’ have special category codes, so to actually use these in a document you have to change their catcodes or use \texttt{\string}.
4 \TeX: Typesetting

\TeX is a typesetting system: it was especially designed to handle complex mathematics, as well as most ordinary text typesetting.

\TeX is a batch language, like C or Pascal, and not an interactive “word processor”: you compile a \TeX input file into a corresponding device-independent (DVI) file (and then translate the DVI file to the commands for a particular output device). This approach has both considerable disadvantages and considerable advantages. For a complete description of the \TeX language, see \textit{The \TeXbook} (see Appendix B [References], page 54). Many other books on \TeX, introductory and otherwise, are available.

4.1 \texttt{tex} invocation

\TeX (usually invoked as \texttt{tex}) formats the given text and commands, and outputs a corresponding device-independent representation of the typeset document. This section merely describes the options available in the Web2c implementation. For a complete description of the \TeX typesetting language, see \textit{The \TeXbook} (see Appendix B [References], page 54).

\TeX, Metafont, and MetaPost process the command line (described here) and determine their memory dump (fmt) file in the same way (see Section 3.5.2 [Memory dumps], page 10). Synopses:

\begin{verbatim}
tex [option]... [texname[.tex]] [tex-commands]
tex [option]... \! \first-line
tex [option]... &fmt args
\end{verbatim}

\TeX searches the usual places for the main input file \texttt{texname} (see Section “Supported file formats” in \textit{Kpathsea}), extending \texttt{texname} with \texttt{.tex} if necessary. To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to ‘-1’ before running the program.

After \texttt{texname} is read, \TeX processes any remaining \texttt{tex-commands} on the command line as regular \TeX input. Also, if the first non-option argument begins with a \TeX escape character (usually \textbackslash{}), \TeX processes all non-option command-line arguments as a line of regular \TeX input.

If no arguments or options are specified, \TeX prompts for an input file name with ‘**’.

\TeX writes the main DVI output to the file \texttt{basetexname.dvi}, where \texttt{basetexname} is the basename of \texttt{texname}, or ‘\texttt{texput}’ if no input file was specified. A DVI file is a device-independent binary representation of your \TeX document. The idea is that after running \TeX, you translate the DVI file using a separate program to the commands for a particular output device, such as a PostScript printer (see Section “Introduction” in \textit{Dvips}) or an X Window System display (see \texttt{xdvi(1)}).

\TeX also reads TFM files for any fonts you load in your document with the \texttt{\font} primitive. By default, it runs an external program named \texttt{mktexfm} to create any nonexistent TFM files. You can disable this at configure-time or runtime (see Section “mktex configuration” in \textit{Kpathsea}). This is enabled mostly for the sake of the EC fonts, which can be generated at any size.

\TeX can write output files, via the \texttt{\openout} primitive; this opens a security hole vulnerable to Trojan horse attack: an unwitting user could run a \TeX program that overwrites, say, ‘\texttt{/\.rhosts}’. (MetaPost has a \texttt{write} primitive with similar implications). To alleviate
this and similar problems the functions `kpathsea_out_name_ok` and `kpathsea_in_name_ok` from the Kpathsea library (see Section “Calling sequence” in Kpathsea) are used to determine if a given filename is acceptable to be opened for output or input, depending on the setting of the configuration variables `openout_any` and `openin_any`: ‘a’ (for “any”, the default for `openin_any`), ‘r’ (for “restricted”), or ‘p’ (for “paranoid”, the default for `openout_any`).

In any case, all `\openout` filenames are recorded in the log file, except those opened on the first line of input, which is processed when the log file has not yet been opened.

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-enc’
‘-\[no\]-file-line-error’
‘-fmt=fmtname’
‘-halt-on-error’
‘-ini’
‘-interaction=string’
‘-ipc’
‘-ipc-start’
‘-jobname=string’
‘-kpathsea-debug=number’
‘-\[no\]parse-first-line’
‘-output-directory’
‘-profilename=string’
‘-recorder’
‘-translate-file=tcxfile’
‘-8bit’

These options are common to \TeX\, Metafont, and MetaPost. See Section 3.2 [Common options], page 7.

‘-enc’

Enable `encteX` extensions, such as `\mubyte`. This can be used to support Unicode UTF-8 input encoding. See [http://www.olsak.net/enctex.html](http://www.olsak.net/enctex.html).

‘-ipc’
‘-ipc-start’

With either option, \TeX\ writes its DVI output to a socket as well as to the usual `.dvi` file. With ‘-ipc-start’, \TeX\ also opens a server program at the other end to read the output. See Section 4.6 [IPC and \TeX\], page 23.

These options are available only if the ‘--enable-ipc’ option was specified to configure during installation of Web2c.

‘-mktex=filetype’
‘-no-mktex=filetype’

Turn on or off the ‘mktex’ script associated with `filetype`. For \TeX\ proper, `filetype` can only be ‘tex’ and ‘tfm’, but for pdf\TeX\ and lua\TeX\, it can also be ‘pk’.

‘-mltex’

If we are \INITEX\ (see Section 3.5.1 [Initial and virgin], page 10), enable ML\TeX\ extensions such as `\charsubdef`. Implicitly set if the program name is `mltex`. See Section 4.4.1 [ML\TeX\], page 19.
'\-output-comment=string'
Use string as the DVI file comment. Ordinarily, this comment records the date and time of the \TeX run, but if you are doing regression testing, you may not want the DVI file to have this spurious difference. This is also taken from the environment variable and config file value 'output_comment'.

'\-shell-escape'
'\-no-shell-escape'
'\-shell-restricted'
Enable, or disable, or enable with restrictions the \write18{shell-command} feature for external executing shell commands. See Section 4.5 [Shell escapes], page 22.

'\-enable-write18'
'\-disable-write18'
Synonyms for '\-shell-escape' and '\-no-shell-escape', for compatibility with MiK\TeX. (MiK\TeX also accepts both pairs of options.) See Section 4.5 [Shell escapes], page 22.

'\-src-specials'
'\-src-specials=string'
This option makes \TeX output specific source information using '\special' commands in the DVI file. These '\special' track the current file name and line number.
Using the first form of this option, the '\special' commands are inserted automatically.
In the second form of the option, string is a comma separated list of the following values: 'cr', 'display', 'bbox', 'math', 'par', 'parent', 'vbox'. You can use this list to specify where you want \TeX to output such commands. For example, '\-src-specials=cr,math' will output source information every line and every math formula.
These commands can be used with the appropriate DVI viewer and text editor to switch from the current position in the editor to the same position in the viewer and back from the viewer to the editor.
This option works by inserting '\special' commands into the token stream, and thus in principle these additional tokens can be recovered or seen by the tricky-enough macros. If you run across a case, let us know, because this counts as a bug. However, such bugs are very hard to fix, requiring significant changes to \TeX, so please don’t count on it.
Redefining '\special' will not affect the functioning of this option. The commands inserted into the token stream are hard-coded to always use the '\special' primitive.
\TeX does not pass the trip test when this option is enabled.

4.2 Initial \TeX
The initial form of \TeX is invoked by 'tex -ini'. It does lengthy initializations avoided by the "virgin" (vir) form, so as to be capable of dumping '.fmt' files (see Section 3.5.2
For a detailed comparison of virgin and initial forms, see Section 3.5.1 [Initial and virgin], page 10.

For a list of options and other information, see Section 4.1 [tex invocation], page 15.

Unlike Metafont and MetaPost, many format files are commonly used with \TeX. The standard one implementing the features described in the \TeXbook is `plain.fmt', also known as `\textfmt' (again, see Section 3.5.2 [Memory dumps], page 10). It is created by default during installation, but you can also do so by hand if necessary (e.g., if an update to plain.tex is issued):

\begin{verbatim}
tex -ini '\input plain \dump'
\end{verbatim}

(The quotes prevent interpretation of the backslashes from the shell.) Then install the resulting plain.fmt in `$\fmtdir' (/usr/local/share/texmf/web2c by default), and link tex.fmt to it.

The necessary invocation for generating a format file differs for each format, so instructions that come with the format should explain. The top-level web2c Makefile has targets for making most common formats: \texttt{plain latex amstex texinfo eplain}. See Section 4.3 [Formats], page 18, for more details on \TeX formats.

### 4.3 Formats

\TeX formats are large collections of macros, often dumped into a .fmt file (see Section 3.5.2 [Memory dumps], page 10) by tex -ini (see Section 4.2 [Initial \TeX], page 17). A number of formats are in reasonably widespread use, and the Web2c Makefile has targets to make the versions current at the time of release. You can change which formats are automatically built by setting the f\textit{fmts} Make variable; by default, only the `plain' and `latex' formats are made.

You can get the latest versions of most of these formats from the CTAN archives in subdirectories of \texttt{CTAN:/macros} (for CTAN info, see Section “unixtex.ftp” in \texttt{Kpathsea}). The archive ftp://ftp.tug.org/tex/lib.tar.gz (also available from CTAN) contains most of these formats (although perhaps not the absolute latest version), among other things.

- **latex**: The most widely used format. The current release is named ‘\LaTeX 2e'; new versions are released approximately every six months, with patches issued as needed. The old release was called ‘\LaTeX 2.09', and is no longer maintained or supported. \LaTeX\ attempts to provide generic markup instructions, such as “emphasize”, instead of specific typesetting instructions, such as “use the 10 pt Computer Modern italic font”. The \LaTeX\ home page: \url{http://www.latex-project.org}.

- **context**: Con\TeXt\ is an independent macro package which has a basic document structuring approach similar to \LaTeX. It also supports creating interactive PDF files and has integrated MetaPost support, among many other interesting features. The Con\TeXt\ home page: \url{http://www.pragma-ade.com}.

- **amstex**: The official typesetting system of the American Mathematical Society. Like \LaTeX, it encourages generic markup commands. The AMS also provides many \LaTeX package for authors who prefer \LaTeX. Taken together, they are used
to produce nearly all AMS publications, e.g., Mathematical Reviews. The AMSTeX home page: http://www.ams.org/tex.

texinfo The documentation system developed and maintained by the Free Software Foundation for their software manuals. It can be automatically converted into plain text, a machine-readable on-line format called ‘info’, HTML, etc. The Texinfo home page: http://www.gnu.org/software/texinfo.

eplain The “expanded plain” format provides various common features (e.g., symbolic cross-referencing, tables of contents, indexing, citations using BibTeX), for those authors who prefer to handle their own high-level formatting. The Eplain home page: http://www.tug.org/eplain.

slitex An obsolete TeX 2.09 format for making slides. It is replaced by the ‘slides’ document class, along with the ‘beamer’, ‘texpower’, and other packages.

4.4 Languages and hyphenation

LaTeX supports most natural languages. See also Section 4.7 [LaTeX extensions], page 23.

4.4.1 MLTeX: Multi-lingual TeX

Multi-lingual TeX (mltex) is an extension of TeX originally written by Michael Ferguson and now updated and maintained by Bernd Raichle. It allows the use of non-existing glyphs in a font by declaring glyph substitutions. These are restricted to substitutions of an accented character glyph, which need not be defined in the current font, by its appropriate \accent construction using a base and accent character glyph, which do have to exist in the current font. This substitution is automatically done behind the scenes, if necessary, and thus MLTeX additionally supports hyphenation of words containing an accented character glyph for fonts missing this glyph (e.g., Computer Modern). Standard TeX suppresses hyphenation in this case.

MLTeX works at .fmt-creation time: the basic idea is to specify the ‘-mltex’ option to TeX when you \dump a format. Then, when you subsequently invoke TeX and read that .fmt file, the MLTeX features described below will be enabled.

Generally, you use special macro files to create an MLTeX .fmt file.

The sections below describe the two new primitives that MLTeX defines. Aside from these, MLTeX is completely compatible with standard TeX.

4.4.1.1 \charsubdef: Character substitutions

The most important primitive MLTeX adds is \charsubdef, used in a way reminiscent of \chardef:

\charsubdef composite [=] accent base

Each of composite, accent, and base are font glyph numbers, expressed in the usual TeX syntax: ‘\e symbolically, ’145 for octal, ”65 for hex, 101 for decimal.

MLTeX’s \charsubdef declares how to construct an accented character glyph (not necessarily existing in the current font) using two character glyphs (that do exist). Thus it defines whether a character glyph code, either typed as a single character or using the \char primitive, will be mapped to a font glyph or to an \accent glyph construction.
For example, if you assume glyph code 138 (decimal) for an e-circumflex (ê) and you are using the Computer Modern fonts, which have the circumflex accent in position 18 and lowercase ‘e’ in the usual ASCII position 101 decimal, you would use \charsubdef as follows:

\charsubdef 138 = 18 101

For the plain \TeX format to make use of this substitution, you have to redefine the circumflex accent macro \^ in such a way that if its argument is character ‘e’ the expansion \char138 is used instead of \accent18 e. Similar \charsubdef declaration and macro redefinitions have to be done for all other accented characters.

To disable a previous \charsubdef c, redefine c as a pair of zeros. For example:

\charsubdef '321 = 0 0  \% disable N tilde

(Octal ’321 is the ISO Latin-1 value for the Spanish N tilde.)

\charsubdef commands should only be given once. Although in principle you can use \charsubdef at any time, the result is unspecified. If \charsubdef declarations are changed, usually either incorrect character dimensions will be used or ML\TeX will output missing character warnings. (The substitution of a \charsubdef is used by \TeX when appending the character node to the current horizontal list, to compute the width of a horizontal box when the box gets packed, and when building the \accent construction at \shipout-time. In summary, the substitution is accessed often, so changing it is not desirable, nor generally useful.)

4.4.1.2 \tracingcharsubdef: Substitution diagnostics

To help diagnose problems with \charsubdef, ML\TeX provides a new primitive parameter, \tracingcharsubdef. If positive, every use of \charsubdef will be reported. This can help track down when a character is redefined.

In addition, if the \TeX parameter \tracinglostchars is 100 or more, the character substitutions actually performed at \shipout-time will be recorded.

4.4.2 TCX files: Character translations

TCX (\TeX character translation) files help \TeX support direct input of 8-bit international characters if fonts containing those characters are being used. Specifically, they map an input (keyboard) character code to the internal \TeX character code (a superset of ASCII).

Of the various proposals for handling more than one input encoding, TCX files were chosen because they follow Knuth’s original ideas for the use of the ‘\xchr’ and ‘\xord’ tables. He ventured that these would be changed in the WEB source in order to adjust the actual version to a given environment. It turns out, however, that recompiling the WEB sources is not as simple a task as Knuth may have imagined; therefore, TCX files, providing the possibility of changing of the conversion tables on-the-fly, have been implemented instead.

This approach limits the portability of \TeX documents, as some implementations do not support it (or use a different method for input-internal reencoding). It may also be problematic to determine the encoding to use for a \TeX document of unknown provenance; in the worst case, failure to do so correctly may result in subtle errors in the typeset output. But we feel the benefits outweigh these disadvantages.
This is entirely independent of the ML\TeX\ extension (see Section 4.4.1 [ML\TeX], page 19): whereas a TCX file defines how an input keyboard character is mapped to \TeX\'s internal code, ML\TeX\ defines substitutions for a non-existing character glyph in a font with a $\texttt{\textbackslash accent}$ construction made out of two separate character glyphs. TCX files involve no new primitives; it is not possible to specify that an input (keyboard) character maps to more than one character.

Information on specifying TCX files:

- The best way to specify a TCX file is to list it explicitly in the first line of the main document:
  
  \%& -translate-file=tcxfile

- You can also specify a TCX file to be used on a particular \TeX\ run with the command-line option ‘-translate-file=tcxfile’.

- TCX files are searched for along the \texttt{WEB2C} path.

- Initial \TeX\ (see Section 4.2 [Initial \TeX\], page 17) ignores TCX files.

The Web2c distribution comes with a number of TCX files. Two important ones are \texttt{il1-t1.tcx} and \texttt{il2-t1.tcx}, which support ISO Latin 1 and ISO Latin 2, respectively, with Cork-encoded fonts (a.k.a. the \LaTeX T1 encoding). TCX files for Czech, Polish, and Slovak are also provided.

One other notable TCX file is \texttt{empty.tcx}, which is, well, empty. Its purpose is to reset Web2C’s behavior to the default (only visible ASCII being printable, as described below) when a format was dumped with another TCX being active—which is in fact the case for everything but plain \TeX\ in the TeX Live and other distributions. Thus:

\begin{verbatim}
latex somefile8.tex
⇒ terminal etc. output with 8-bit chars
latex --translate-file=empty.tcx somefile8.tex
⇒ terminal etc. output with "" notation
\end{verbatim}

Syntax of TCX files:

1. Line-oriented. Blank lines are ignored.
2. Whitespace is ignored except as a separator.
3. Comments start with ‘\%’ and continue to the end of the line.
4. Otherwise, a line consists of one or two character codes, optionally followed by 0 or 1. The last number indicates whether dest is considered printable.

\texttt{src [dest [prnt]]}

5. Each character code may be specified in octal with a leading ‘0’, hexadecimal with a leading ‘0x’, or decimal otherwise. Values must be between 0 and 255, inclusive (decimal).

6. If the dest code is not specified, it is taken to be the same as src.

7. If the same src code is specified more than once, it is the last definition that counts.

Finally, here’s what happens: when \TeX\ sees an input character with code src, it 1) changes src to dest; and 2) makes the dest code “printable”, i.e., printed as-is in diagnostics and the log file rather than in ‘\textbackslash^\textbackslash’ notation.
By default, no characters are translated, and character codes between 32 and 126 inclusive (decimal) are printable.

Specifying translations for the printable ASCII characters (codes 32–127) will yield unpredictable results. Additionally, you shouldn’t make the following characters printable: \^\textbackslash I (TAB), \^\textbackslash J (line feed), \^\textbackslash M (carriage return), and \^\textbackslash ? (delete), since \TeX uses them in various ways.

Thus, the idea is to specify the input (keyboard) character code for $src$, and the output (font) character code for $dest$.

By default, only the printable ASCII characters are considered printable by \TeX. If you specify the ‘-8bit’ option, all characters are considered printable by default. If you specify both the ‘-8bit’ option and a TCX file, then the TCX can set specific characters to be non-printable.

Both the specified TCX encoding and whether characters are printable are saved in the dump files (like \texttt{tex.fmt}). So by giving these options in combination with ‘-ini’, you control the defaults seen by anyone who uses the resulting dump file.

When loading a dump, if the ‘-8bit’ option was given, then all characters become printable by default.

When loading a dump, if a TCX file was specified, then the TCX data from the dump is ignored and the data from the file used instead.

### 4.4.3 Patgen: Creating hyphenation patterns

Patgen creates hyphenation patterns from dictionary files for use with \TeX. Synopsis:

```
patgen dictionary patterns output translate
```

Each argument is a filename. No path searching is done. The output is written to the file \texttt{output}.

In addition, Patgen prompts interactively for other values.

For more information, see Word hyphenation by computer by Frank Liang (see Appendix B [References], page 54), and also the \texttt{patgen.web} source file.

The only options are ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7).

### 4.5 Shell escapes

\TeX can execute shell escapes, that is, arbitrary shell commands. Although tremendously useful, this also has obvious security implications. Therefore, as of \TeX Live 2009, a restricted mode for shell escapes is the default mode of operation, which allows executing only certain commands, as specified in the \texttt{texmf.cnf} configuration file.

- Unrestricted shell escapes are allowed if the option \texttt{--shell-escape} is specified, or if the environment variable or config value \texttt{shell_escape} is set to ‘t’ or ‘y’ and ‘1’.
- Restricted shell escapes are allowed if \texttt{shell_escape} is set to ‘p’. This is the default.
- Shell escapes are completely disabled if \texttt{--no-shell-escape} is specified, or if \texttt{shell_escape} is set to anything else.

When enabled, the \TeX construct to execute a system command is \texttt{\write18{shell-command}}; for example:

```
\write18{echo "hello, world"}
```
Chapter 4: \TeX: Typesetting

From \TeX's point of view, this is a normal \texttt{\textbackslash write} command, and is therefore subject to the usual \TeX expansions. Also, the system call either happens during the \texttt{\textbackslash output} routine or right away, according to the absence or presence of the \texttt{\textbackslash immediate} prefix, as usual for \texttt{\textbackslash write}.

The \texttt{\textbackslash shell-command} string is passed to the command shell (via the C library function \texttt{system}). The output of \texttt{\textbackslash shell-command} is not diverted anywhere, so it will not appear in the log file, or anywhere but the terminal output. The exit status of the system call is also not available to \TeX.

In unrestricted mode, the argument is simply passed straight to \texttt{system} unaltered.

In restricted mode, ASCII double quote characters ("%) should always be used in the argument to \texttt{\textbackslash write18} where quoting of arguments is needed, as in the example above. This is to achieve some measure of system independence. On Unix systems, these are replaced with single quote ('') characters to avoid insecure further expansion. Care is also taken on Windows to avoid additional expansions (from, e.g., '...'). Mismatched quotation marks in the command string result in a diagnostic message in the log file; no execution is performed.

After quotation processing, if the first word (delimited by a space or tab) of the command is in the list specified by the \texttt{\textbackslash shell_escape_commands} configuration value, the command is executed. Otherwise it is not. In any case, a message is written to the log file.

The \texttt{\textbackslash shell_escape_commands} value is a comma-separated list of words. Whitespace is significant, and typically should not be present. The default definition in \texttt{\texttt{texmf.cnf}} looks like this, but with more commands included:

\begin{verbatim}
shell_escape_commands = bibtex,kpsewhich,repstopdf,..
\end{verbatim}

\TeX and lua\TeX support reading (via \texttt{\textbackslash input} and \texttt{\textbackslash openin}) and writing (via \texttt{\textbackslash openout}) from pipes if the first character is '|'. The following command is then treated exactly the same as the argument to \texttt{\textbackslash write18}. In these engines, the primitive variable \texttt{\textbackslash pdfshellescape} is set to 0 if shell escapes are disabled, 1 if they are enabled, and 2 if they are enabled with restrictions.

The purpose of this feature is to make it possible for \TeX documents to perform useful external actions in the common case of an individual user running a known document on his or her own machine. In such environments as CGI scripts or wikis where the input has to be considered untrustworthy, shell escapes should be completely disabled.

4.6 IPC and \TeX

(If anyone uses this feature and needs documentation, write tex-k@tug.org.)

This functionality is available only if the \texttt{\textbackslash --enable-ipc} option was specified to \texttt{\textbackslash configure} during installation of Web2c (see Chapter 2 [Installation], page 2).

If you define \texttt{\textbackslash IPC_DEBUG} before compilation (e.g., with \texttt{\textbackslash make XCFLAGS=-DIPC_DEBUG}), \TeX will print messages to standard error about its socket operations. This may be helpful if you are, well, debugging.

4.7 \TeX extensions

The base \TeX program has been extended in many ways. Here's a partial list.
e-TEX  Adds many new primitives, including right-to-left typesetting and more registers. Now frozen.

Aleph  This adds Unicode support, right-to-left typesetting, and more. Omega was the original program. Aleph is an updated version with a variety of bug fixes, and includes e-TEX. Aleph is not actively maintained.

pdfTeX  Can produce PDF as well as DVI files. It also incorporates the e-TEX extensions, new primitives for hypertext and micro-typography, reading/writing from pipes, and much more. Home page: http://pdftex.org.

luaTeX  Based on pdfTeX, this also embeds the Lua programming language (http://lua.org) and opens up the TeX typesetting engine to control from Lua. Home page: http://luatex.org.

XeTeX  Combines support for Unicode input and OpenType- and system fonts with the capabilities of pdfTeX. Home page: http://tug.org/xetex.
5 Metafont: Creating typeface families

Metafont is a system for producing shapes; it was designed for producing complete typeface families, but it can also produce geometric designs, dingbats, etc. And it has considerable mathematical and equation-solving capabilities which can be useful entirely on their own.

Metafont is a batch language, like C or Pascal: you compile a Metafont program into a corresponding font, rather than interactively drawing lines or curves. This approach has both considerable disadvantages (people unfamiliar with conventional programming languages will be unlikely to find it usable) and considerable advantages (you can make your design intentions specific and parameterizable). For a complete description of the Metafont language, see The METAFONTbook (see Appendix B [References], page 54).

5.1 mf invocation

Metafont (usually invoked as mf) reads character definitions specified in the Metafont programming language, and outputs the corresponding font. This section merely describes the options available in the Web2c implementation. For a complete description of the Metafont language, see The Metafontbook (see Appendix B [References], page 54).

Metafont processes its command line and determines its memory dump (base) file in a way exactly analogous to MetaPost and TEX (see Section 4.1 [tex invocation], page 15, and see Section 3.5.2 [Memory dumps], page 10). Synopses:

\texttt{mf \[option]\ldots \[mfname\.mf\] \[mf\text{-commands}\] \[first-line\] \&base args}

Most commonly, a Metafont invocation looks like this:

\begin{verbatim}
mf '\mode:=mode; mag:=magnification; input mfname'
\end{verbatim}

(The single quotes avoid unwanted interpretation by the shell.)

Metafont searches the usual places for the main input file \texttt{mfname} (see Section “Supported file formats” in Kpathsea), extending \texttt{mfname} with \texttt{.mf} if necessary. To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to ‘\texttt{-1}’ before running the program. By default, Metafont runs an external program named \texttt{mktexmf} to create any nonexistent Metafont source files you input. You can disable this at configure-time or runtime (see Section “mktex configuration” in Kpathsea). This is mostly for the sake of the EC fonts, which can be generated at any size.

Metafont writes the main GF output to the file \texttt{basemfname.nnngf}, where \texttt{nnn} is the font resolution in pixels per inch, and \texttt{basemfname} is the basename of \texttt{mfname}, or ‘mfput’ if no input file was specified. A GF file contains bitmaps of the actual character shapes. Usually GF files are converted immediately to PK files with GFToPK (see Section 10.2 [gftopk invocation], page 45), since PK files contain equivalent information, but are more compact. (Metafont output in GF format rather than PK for only historical reasons.)

Metafont also usually writes a metric file in TFM format to \texttt{basemfname.tfm}. A TFM file contains character dimensions, kerns, and ligatures, and spacing parameters. TEX reads only this .tfm file, not the GF file.

The \texttt{mode} in the example command above is a name referring to a device definition (see Section 5.3 [Modes], page 27); for example, \texttt{localfont} or \texttt{ljfour}. These device definitions
must generally be precompiled into the base file. If you leave this out, the default is proof mode, as stated in *The Metafontbook*, in which Metafont outputs at a resolution of 2602 dpi; this is usually not what you want. The remedy is simply to assign a different mode—localfont, for example.

The magnification assignment in the example command above is a magnification factor; for example, if the device is 600 dpi and you specify mag := 2, Metafont will produce output at 1200 dpi. Very often, the magnification is an expression such as magstep(.5), corresponding to a TeX “magstep”, which are factors of \(1.2\sqrt{2}\).

After running Metafont, you can use the font in a TeX document as usual. For example:

\begin{verbatim}
\font\myfont = newfont
\myfont Now I am typesetting in my new font (minimum hamburgers).
\end{verbatim}

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-[no]-file-line-error’
‘-fmt=fmtname’
‘-halt-on-error’
‘-ini’
‘-interaction=string’
‘-jobname=string’
‘-kpathsea-debug=number’
‘-[no]parse-first-line’
‘-output-directory’
‘-progname=string’
‘-recorder’
‘-translate-file=tcxfile’
‘-8bit’

These options are common to TeX, Metafont, and MetaPost. See Section 3.2 [Common options], page 7.

‘-mktex=filetype’
‘-no-mktex=filetype’

Turn on or off the ‘mktex’ script associated with filetype. The only value that makes sense for filetype is ‘mf’.

### 5.2 Initial Metafont

inimf is the “initial” form of Metafont, which does lengthy initializations avoided by the “virgin” (vir) form, so as to be capable of dumping ‘.base’ files (see Section 3.5.2 [Memory dumps], page 10). For a detailed comparison of virgin and initial forms, see Section 3.5.1 [Initial and virgin], page 10.

For a list of options and other information, see Section 5.1 [mf invocation], page 25.

The only memory dump file commonly used with Metafont is the default ‘plain.base’, also known as ‘mf.base’ (again, see Section 3.5.2 [Memory dumps], page 10). It is created by default during installation, but you can also do so by hand if necessary (e.g., if a Metafont update is issued):

\begin{verbatim}
mf -ini \input plain; input modes; dump
\end{verbatim}
(The quotes prevent interpretation of the backslashes from the shell.) Then install the resulting plain.base in ‘$(basedir)’ (/usr/local/share/texmf/web2c by default), and link mf.base to it.

For an explanation of the additional modes.mf file, see Section 5.3 [Modes], page 27. This file has no counterpart in \TeX or MetaPost.

In the past, it was sometimes useful to create a base file cmmf.base (a.k.a. cm.base), with the Computer Modern macros also included in the base file. Nowadays, however, the additional time required to read cmbase.mf is exceedingly small, usually not enough to be worth the administrative hassle of updating the cmmf.base file when you install a new version of modes.mf. People actually working on a typeface may still find it worthwhile to create their own base file, of course.

5.3 Modes: Device definitions for Metafont

Running Metafont and creating Metafont base files requires information that \TeX and MetaPost do not: mode definitions which specify device characteristics, so Metafont can properly rasterize the shapes.

When making a base file, a file containing modes for locally-available devices should be input after plain.mf. One commonly used file is ftp://ftp.tug.org/tex/modes.mf; it includes all known definitions.

If, however, for some reason you have decreased the memory available in your Metafont, you may need to copy modes.mf and remove the definitions irrelevant to you (probably most of them) instead of using it directly. (Or, if you’re a Metafont hacker, maybe you can suggest a way to redefine mode_def and/or mode_setup; right now, the amount of memory used is approximately four times the total length of the mode_def names, and that’s a lot.)

If you have a device not included in modes.mf, please see comments in that file for how to create the new definition, and please send the definition to tex-fonts@math.utah.edu to get it included in the next release of modes.mf.

Usually, when you run Metafont you must supply the name of a mode that was dumped in the base file. But you can also define the mode characteristics dynamically, by invoking Metafont with an assignment to smode instead of mode, like this:

\verbatim{mf ’\smode:="newmode.mf"; mag:=magnification; input mfname’}

This is most useful when you are working on the definition of a new mode.

The magnification and mfname arguments are explained in Section 5.1 [mf invocation], page 25. In the file newmode.mf, you should have the following (with no mode_def or enddef), if you are using modes.mf conventions:

```
mode_param (pixels_per_inch, dpi);
mode_param (blacker, b);
mode_param (fillin, f);
mode_param (o_correction, o);
mode_common_setup;
```

(Of course, you should use real numbers for dpi, b, f, and o.)

For more information on the use of smode, or if you are not using modes.mf, see page 269 of The Metafontbook.
### 5.4 Online Metafont graphics

The Web2c implementation of Metafont can do online graphics with a number of devices. (See the Metafont manual for more information about how to draw on your screen.) By default, no graphics support is enabled.

Metafont examines the `MFTERM` environment variable or config file value at runtime, or the `TERM` environment variable if `MFTERM` is not set, to determine the device support to use. Naturally, only the devices for which support has been compiled in can be selected.

Here is a table of the possibilities, showing the `MFTERM` value and the corresponding `configure` option(s) in parentheses.

<table>
<thead>
<tr>
<th>Device</th>
<th><code>configure</code> option(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>epsf</td>
<td><code>--enable-epsfwin</code></td>
<td>Pseudo-window server for Encapsulated PostScript (see <code>web2c/window/epsf.c</code>). This device produces an EPS file containing the graphics which would be displayed online on other devices. The name of the EPS file defaults to <code>metafont.eps</code> but can be changed by setting the <code>MFEPSF</code> environment variable to the new filename. Contributed by Mathias Herberts.</td>
</tr>
<tr>
<td>hp2627</td>
<td><code>--enable-hp2627win</code></td>
<td>HP2627a color graphics terminals.</td>
</tr>
<tr>
<td>mftalk</td>
<td><code>--enable-mftalkwin</code></td>
<td>Generic window server (see <code>web2c/window/mftalk.c</code>).</td>
</tr>
<tr>
<td>next</td>
<td><code>--enable-next</code></td>
<td>NeXT window system. This requires a separate program, called <code>DrawingServant</code>, available separately. See the <code>web2c/window/next.c</code>.</td>
</tr>
<tr>
<td>regis</td>
<td><code>--enable-regiswin</code></td>
<td>Regis terminals.</td>
</tr>
<tr>
<td>sun</td>
<td><code>--enable-suntoolswin</code></td>
<td>The old Suntools (not any flavor of X) window system. (You can get the even older SunWindows <code>gfx</code> system by using <code>sun-gfx.c</code>).</td>
</tr>
<tr>
<td>tek</td>
<td><code>--enable-tektronixwin</code></td>
<td>Tektronix terminals.</td>
</tr>
<tr>
<td>uniterm</td>
<td><code>--enable-unitermwin</code></td>
<td>Uniterm, Simon Poole’s emulator of a smart Tektronix 4014 terminal. This may work with regular Tektronix terminals as well; it’s faster than the driver <code>--enable-tektronixwin</code> selects.</td>
</tr>
<tr>
<td>xterm</td>
<td><code>--with-x</code></td>
<td>The X window system (version 11).</td>
</tr>
</tbody>
</table>

There are two variants of the X11 support, one that works with the Xt toolkit, and another that works directly with Xlib. The Xt support is more efficient and has more functionality, so it is the default. If you must use the Xlib support, use `configure --with-x --with-kf-x-toolkit=no`.

Specify `--disable-mf-nowin` in order not to build a separate non-windows-capable Metafont executable `mf-nowin` (or `mf-nowin.exe`).

You cannot specify any of the usual X options (e.g., `--geometry`) on the Metafont command line, but you can specify X resources in your `~/.Xdefaults` or `~/.Xresources` file. The class name is `Metafont`. If you're using the Xt support, all the usual X toolkit resources are supported. If you're using the Xlib support, only the `geometry` resource is supported.

You specify the X display to which Metafont connects in the `DISPLAY` environment variable, as usual.

Writing support for a new device is straightforward. Aside from defining the basic drawing routines that Metafont uses (see `mf.web`), you only have to add another entry to
the tables on the last page of web2c/lib/texmfmp.c. Or you can write an independent program and use MFtalk (see web2c/window/mftalk.c).

5.5 GFtoDVI: Character proofs of fonts

GFtoDVI makes proof sheets from a GF bitmap file as output by, for example, Metafont (see Chapter 5 [Metafont], page 25). This is an indispensable aid for font designers or Metafont hackers. Synopsis:

 \texttt{gftodvi [option]... gfname[.gf]}

The font \texttt{gfname} is searched for in the usual places (see Section “Glyph lookup” in Kpathsea). To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to ‘-1’ before running the program.

The suffix ‘.gf’ is supplied if not already present. This suffix is not an extension, no ‘.’ precedes it; for instance, \texttt{cmr10.600gf}.

The output filename is the basename of \texttt{gfname} extended with .dvi, e.g., ‘\texttt{gftodvi/wherever/foo.600gf}’ creates ./foo.dvi.

The characters from \texttt{gfname} appear one per page in the DVI output, with labels, titles, and annotations, as specified in Appendix H (Hardcopy Proofs) of The Metafontbook.

GFtoDVI uses several fonts besides \texttt{gfname} itself:

- \textit{gray font} (default \texttt{gray}): for the pixels that actually make up the character. Simply using black is not right, since then labels, key points, and other information could not be shown.
- \textit{title font} (default \texttt{cmr8}): for the header information at the top of each output page.
- \textit{label font} (default \texttt{cmtt10}): for the labels on key points of the figure.
- \textit{slant font} (no default): for diagonal lines, which are otherwise simulated using horizontal and vertical rules.

To change the default fonts, you must use special commands in your Metafont source file, typically via commands like \texttt{slantfont slantlj4}. There is no default slant font since no one printer is suitable as a default. You can make your own by copying one of the existing files, such as .../fonts/source/public/misc/slantlj4.mf and then running \texttt{mf} on it.

For testing purposes, you may it useful to run \texttt{mf-nowin rtest} (hit RETURN when it stops) to get a \texttt{gf} file of a thorn glyph. Or use \texttt{mf} instead of \texttt{mf-nowin} to have the glyph(s) displayed on the screen. After that, \texttt{gftodvi rtest.2602gf} should produce \texttt{rtest.dvi}, which you process as usual.

The program accepts the following option, as well as the standard ‘-verbose’, ‘-help’, and ‘-version’ (see Section 3.2 [Common options], page 7):

\texttt{-overflow-label-offset=points}

Typeset the so-called overflow labels, if any, points \TeX points from the right edge of the character bounding box. The default is a little over two inches (ten million scaled points, to be precise). Overflow equations are used to locate coordinates when their actual position is too crowded with other information.
5.6 MFT: Prettyprinting Metafont source

MFT translates a Metafont program into a \TeX{} document suitable for typesetting, with the aid of \TeX{} macros defined in the file \texttt{mftmac.tex}. Synopsis:

\begin{verbatim}
mft [option]... mfname\.mf
\end{verbatim}

MFT searches the usual places for \textit{mfname} (see Section “Supported file formats” in \texttt{Kpathsea}). To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to ‘-1’ before running the program. The output goes to the basename of \texttt{mfname} extended with \texttt{.tex}, e.g., ‘mft /wherever/foo.mf’ creates ./foo.tex.

Line breaks in the input are carried over into the output; moreover, blank spaces at the beginning of a line are converted to quads of indentation in the output. Thus, you have full control over the indentation and line breaks. Each line of input is translated independently of the others.

Further control is allowed via Metafont comments:

- Metafont comments following a single ‘\%’ should be valid \TeX{} input. But Metafont material can be included within vertical bars in a comment; this will be translated by MFT as if it were regular Metafont code. For example, a comment like ‘\% \{x2r\} is the tip of the bowl’ will be translated into the \TeX{} ‘\% $x_{2r}$ is the ...’, i.e., the ‘\{x2r\}’ is treated as an identifier.
- ‘\%%’ indicates that the remainder of an input line should be copied verbatim to the output. This is typically used to introduce additional \TeX{} material at the beginning or an MFT job, e.g., code to modify the standard layout or the formatting macros defined in \texttt{mftmac.tex}, or to add a line saying ‘\%%\bye’ at the end of the job. (MFT doesn’t add this automatically in order to allow processing several files produces by MFT in the same \TeX{} job.)
- ‘\%%% token1 other-tokens’ introduces a change in MFT’s formatting rules; all the \textit{other-tokens} will henceforth be translated according to the current conventions for \textit{token1}. The tokens must be symbolic (i.e., not numeric or string tokens). For example, the input line
  \begin{verbatim}
  \%%% addto fill draw filldraw
  \end{verbatim}

says to format the ‘\texttt{fill}’, ‘\texttt{draw}’, and ‘\texttt{filldraw}’ operations of plain Metafont just like the primitive token ‘\texttt{addto}’, i.e., in boldface type. Without such reformattning commands, MFT would treat ‘\texttt{fill}’ like an ordinary tag or variable name. In fact, you need a ‘\%%%’ command even to get parentheses to act like delimiters.
- ‘\%%%’ introduces an MFT comment, i.e., MFT ignores the remainder of such a line.
- Five or more ‘\%’ signs should not be used.

(The above description was edited from \texttt{mft.web}, written by D.E. Knuth.)

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-change=chfile\.ch’

Apply the change file \texttt{chfile} as with Tangle and Weave (see Chapter 8 [WEB], page 37).
Read \textit{mftfile} before anything else; a MFT style file typically contains only MFT directives as described above. The default style file is named \texttt{plain.mft}, which defines this properly for programs using plain Metafont. The MFT files is searched along the \texttt{MFTINPUTS} path; see Section "Supported file formats" in \textit{Kpathsea}.

Other examples of MFT style files are \texttt{cmbase.mft}, which defines formatting rules for the macros defined in \texttt{cm.base}, and \texttt{e.mft}, which was used in the production of Knuth’s Volume E, \textit{Computer Modern Typefaces}.

Using an appropriate MFT style file, it is also possible to configure MFT for typesetting MetaPost sources. However, MFT does not search the usual places for MetaPost input files.

If you use eight-bit characters in the input file, they are passed on verbatim to the \TeX output file; it is up to you to configure \TeX to print these properly.
6 MetaPost: Creating technical illustrations

MetaPost is a picture-drawing language similar to Metafont (see Chapter 5 [Metafont], page 25), but instead of outputting bitmaps in a “font”, it outputs PostScript commands. It’s primarily intended for creating technical illustrations.

MetaPost also provides for arbitrary integration of text and graphics in a natural way, using any typesetter ($\TeX$ and Troff are both supported) and a number of other subsidiary programs, described below.

6.1 mpost invocation

MetaPost (installed as mpost) reads a series of pictures specified in the MetaPost programming language, and outputs corresponding PostScript code. This section merely describes the options available in the Web2c implementation. For a complete description of the MetaPost language, see AT&T technical report CSTR-162, generally available in texmf/doc/metapost/, where texmf is the root of $\TeX$ directory structure. See also:

- http://cm.bell-labs.com/who/hobby/MetaPost.html (the MetaPost author’s home page);

Also, a standard MetaPost package for drawing graphs is documented in AT&T technical report CSTR-164, available as the file mpgraph.ps, generally stored alongside mpman.ps.

MetaPost processes its command line and determines its memory dump (mem) file in a way exactly analogous to Metafont and $\TeX$ (see Section 4.1 [tex invocation], page 15, and see Section 3.5.2 [Memory dumps], page 10). Synopses:

```
mpost [option]... [mpname.mp] [mp-commands]
mpost [option]... \first-line
mpost [option]... &mem args
```

MetaPost searches the usual places for the main input file mpname (see Section “Supported file formats” in Kpathsea), extending mpname with .mp if necessary. To see all the relevant paths, set the environment variable KPATHSEA_DEBUG to ‘-1’ before running the program.

MetaPost writes its PostScript output to a series of files basename.mnn (or perhaps basename.ps, very occasionally basename.tfm), where mnn are the figure numbers specified in the input, typically to the beginfig macro, and basename is the basename of mpname, or ‘mpout’ if no input file was specified. MetaPost uses the ‘.ps’ extension when the figure number is out of range, e.g., if you say beginfig(-1).

You can use the output files as figures in a $\TeX$ document just as with any other PostScript figures. For example, with this $\TeX$ command:

```
\special{psfile="filename"}
```

or by using epsf.tex (see Section “EPSF macros” in Dvips).

The MetaPost construct

```
btex ... tex-input ... etex
```

generates a MetaPost picture expression corresponding to tex-input.
The construct

verbatimtex ... tex-input ... etex

simply passes the *tex-input* through to \TeX. For example, if you are using \LaTeX, your MetaPost input file must start with a verbatimtex block that gives the necessary \documentclass (or \documentstyle) \begin{document} command. You will also need to set the environment variable \TeX{} to \texttt{latex}'.

*tex-input* need not be specifically \TeX{} input; it could also be Troff. In that case, you will need the \texttt{-m pictures} Troff macro package (unfortunately absent from many Troff implementations), or an equivalent such as the \texttt{-m pspic} macros from GNU groff described in \texttt{groff(1)}.

Naturally, you must use fonts that are supported by the typesetter; specifically, you'll probably want to use standard PostScript fonts with Troff. And only the \TeX{} system understands Computer Modern or other Metafont fonts; you can also use PostScript fonts with \TeX{}, of course.

MetaPost-generated PostScript figures which do use Computer Modern fonts for labels cannot be directly previewed or printed. Instead, you must include them in a \TeX{} document and run the resulting DVI file through Dvips to arrange for the downloading of the required fonts (see Section “Fonts in figures” in \texttt{Dvips}). To help with this, the MetaPost distribution provides a small \TeX{} file \texttt{mproof.tex} which is typically called as:

\texttt{tex mproof mp-output-files... ; dvips mproof -o}

The resulting file \texttt{mproof.ps} can then be printed or previewed.

To generate EPSF files, set the internal MetaPost variable \texttt{prologues} positive. To make the output files self-contained, use only standard PostScript fonts. MetaPost reads the same \texttt{psfonts.map} file as Dvips, to determine PostScript fonts that need to be downloaded (see Section “psfonts.map” in \texttt{Dvips}).

It is possible for pdf\TeX{} to read MetaPost output directly; this is in contrast to general EPSF files, which have to be converted for use with PDF output. The easiest way is to name the MetaPost output files with the \texttt{.mps} extension. Then the \LaTeX{} \texttt{\includegraphics} command, for example, will be able to read them, even when outputting PDF.

MetaPost can write output files, via the \texttt{write} primitive; this opens a security hole. See Section 4.1 [tex invocation], page 15.

The program accepts the following options, as well as the standard \texttt{\-help} and \texttt{\-version} (see Section 3.2 [Common options], page 7):
Chapter 6: MetaPost: Creating technical illustrations

\begin{itemize}
  \item `-file-line-error`
  \item `-fmt=fmtname`
  \item `-halt-on-error`
  \item `-ini`
  \item `-interaction=string`
  \item `-jobname=string`
  \item `-kpathsea-debug=number`
  \item `-no-parse-first-line`
  \item `-output-directory`
  \item `-progname=string`
  \item `-recorder`
  \item `-translate-file=tcxfile`
  \item `-8bit`
\end{itemize}

These options are common to \TeX, Metafont, and MetaPost. See Section 3.2 [Common options], page 7.

`-T`

`-troff` Set the prologues internal variable to 1.

`-tex=texprogram`

When this option is given, the program texprogram is used to typeset the labels.

\section*{6.2 Initial MetaPost}

As of MetaPost 1.504 (\TeX Live 2011), MetaPost no longer dumps .mem files (see Section 3.5.2 [Memory dumps], page 10) and does not distinguish virgin and initial forms (see Section 3.5.1 [Initial and virgin], page 10). Instead, the “initial” file name is read in its source form—that is, \texttt{mpost.mp} when the program is invoked as \texttt{mpost}.

For a list of options and other information, see Section 6.1 [mpost invocation], page 32.

MetaPost provides a format with all the features of plain Metafont, called \texttt{mfplain}. You can use that in the same way; just run \texttt{mfplain} instead of \texttt{mpost}. This lets you directly process Metafont source files with MetaPost, producing character proofs (one file for each character) similar to those produced with Metafont in proof mode and GForgDVI (see Section 5.5 [gftodvi invocation], page 29).

\section*{6.3 DVItoMP: DVI to MPX conversion}

DVItoMP converts DVI files into low-level MetaPost commands in a so-called MPX file. Synopsis:

\begin{verbatim}
dvitomp dvifile[.dvi] [mpxfile[.mpx]]
\end{verbatim}

If \texttt{mpxfile} is not specified, the output goes to the basename of \texttt{dvifile} extended with \texttt{.mpx}, e.g., `dvitomp /wherever/foo.dvi' creates `/foo.mpx'.

DVItoMP supports Dvips-style color specials, such as `color push name' and `color pop', outputting them as \texttt{withcolor} MetaPost commands.

The only options are `-help' and `-version' (see Section 3.2 [Common options], page 7).
7 Bib\TeX: Bibliographies

Bib\TeX automates much of the job of typesetting bibliographies, and makes bibliography entries reusable in many different contexts.

7.1 Bib\TeX invocation

Bib\TeX creates a printable bibliography (.bbl) file from references in a .aux file, generally written by \TeX or \LaTeX. The .bbl file is then incorporated on a subsequent run. The basic bibliographic information comes from .bib files, and a Bib\TeX style (.bst) file controls the precise contents of the .bbl file. Synopsis:

\texttt{bibtex [option]... auxfile[.aux]}

The output goes to the basename of auxfile extended with .bbl; for example, ‘\texttt{bibtex /wherever/foo.aux}’ creates ./foo.bbl. Bib\TeX also writes a log file to the basename of auxfile extended with ‘.blg’.

The names of the .bib and .bst files are specified in the .aux file as well, via the \texttt{\bibliography} and \texttt{\bibliographystyle} (La)\TeX macros. Bib\TeX searches for .bib files using the \texttt{BIBINPUTS} and \texttt{TEXBIB} paths, and for .bst files using \texttt{BSTINPUTS} (see Section “Supported file formats” in \texttt{Kpathsea}). It does no path searching for .aux files.

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-terse’ Suppress the program banner and progress reports normally output.

‘-min-crossrefs=n’

If at least \(n\) (2 by default) bibliography entries refer to another entry \(e\) via their crossref field, include \(e\) in the .bbl file, even if it was not explicitly referenced in the .aux file. For example, \(e\) might be a conference proceedings as a whole, with the cross-referencing entries being individual articles published in the proceedings.

If you want to avoid these automatic inclusions altogether, make \(n\) a sufficiently large number, and be sure to remove any previous .aux and .bbl files. Otherwise the option may appear to have no effect, since Bib\TeX will have added the citation for \(e\) to the .aux, and nothing will remove it.

See also:

\texttt{btxdoc.tex}

Basic \LaTeX\xspaceable documentation for general Bib\TeX users.

\texttt{btxhak.tex}

\LaTeX\xspaceable documentation for style designers.

\texttt{btxdoc.bib}

Bib\TeX database file for the two above documents.

\texttt{xampl.bib}

Example database file with all the standard entry types.

\texttt{ftp://ftp.math.utah.edu/pub/tex/bib/}

A very large .bib and .bst collection, including references for all the standard \TeX books and a complete bibliography for TUGboat.
7.2 Basic Bib\TeX style files

Here are descriptions of the four standard and four semi-standard basic Bib\TeX styles. CTAN:/biblio/bibtex contains these and many more (for CTAN info, see Section “unix-tex.ftp” in Kpathsea).

- **plain**: Sorts entries alphabetically, with numeric labels. Generally formatted according to van Leunen’s *A Handbook for Scholars*. The other style files listed here are based on plain.
- **abbrv**: First names, month names, and journal names are abbreviated.
- **acm**: Names are printed in small caps.
- **alpha**: Alphanumeric labels, e.g., ‘Knu66’.
- **apalike**: No labels at all; instead, the year appears in parentheses after the author. Use this in conjunction with apalike.tex (plain TeX) or apalike.sty (LaTeX), which also changes the citations in the text to be ‘(author, year)’.
- **ieeetr**: Numeric labels, entries in citation order, IEEE abbreviations, article titles in quotes.
- **siam**: Numeric labels, alphabetic order, Math. Reviews abbreviations, names in small caps.
- **unsrt**: Lists entries in citation order, i.e., unsorted.

**btxbst.doc**

The template file and documentation for the standard styles.
WEB: Literate programming

WEB languages allow you to write a single source file that can produce both a compilable program and a well-formatted document describing the program in as much detail as you wish to prepare. Writing in this kind of dual-purpose language is called *literate programming*. (The Usenet newsgroup *comp.programming.literate* is devoted to this subject.)

WEB-like languages have been implemented with many pairs of base languages: Cweb provides C and Troff (see Appendix B [References], page 54); CWEB provides C and T\TeX\ (CTAN:/web/c_cpp/cweb); Spiderweb provides C, C++, Awk, Ada, many others, and T\TeX\ (CTAN:/web/spiderweb); and, of course, the original WEB provides Pascal and T\TeX, the implementation languages for the original T\TeX, Metafont, MetaPost, and related programs to come from the T\TeX\ project at Stanford.

The original WEB language is documented in the file *webman.tex*, which is included in the ftp://ftp.tug.org/tex/lib.tar.gz archive (and available in many other places, of course).

8.1 Tangle: Translate WEB to Pascal

Tangle creates a compilable Pascal program from a WEB source file (see Chapter 8 [WEB], page 37). Synopsis:

```
tangle [option]... webfile[.web] [changefile[.ch]]
```

The Pascal output is written to the basename of *webfile* extended with ‘.p’; for example, ‘tangle /wherever/foo.web’ creates /foo.p. Tangle applies *changefile* to *webfile* before writing the output; by default, there is no change file.

If the program makes use of the WEB string facility, Tangle writes the string pool to the basename of *webfile* extended with ‘.pool’.

The Pascal output is packed into lines of 72 characters or less, with the only concession to readability being the termination of lines at semicolons when this can be done conveniently.

The program accepts the following options, as well as the standard ‘--help’ and ‘--version’ (see Section 3.2 [Common options], page 7):

‘-length=number’

The number of characters that are considered significant in an identifier. Whether underline characters are counted depends on the ‘-underline’ option. The default value is 32, the original tangle used 7, but this proved too restrictive for use by Web2c.

‘-lowercase’
‘-mixedcase’
‘-uppercase’

These options specify the case of identifiers in the output of tangle. If ‘-uppercase’ (‘-lowercase’) is specified, tangle will convert all identifiers to uppercase (lowercase). The default is ‘-mixedcase’, which specifies that the case will not be changed.

‘-underline’

When this option is given, tangle does not strip underline characters from identifiers.
These options specify how strict tangle must be when checking identifiers for equality. The default is `loose`, which means that tangle will follow the rules set by the case-smashing and underline options above. If `strict` is set, then identifiers will always be stripped of underlines and converted to uppercase before checking whether they collide.

### 8.2 Weave: Translate WEB to \TeX\n
Weave creates a \TeX\ document from a WEB source file (see Chapter 8 [WEB], page 37), assuming various macros defined in `webmac.tex`. It takes care of typographic details such as page layout, indentation, and italicizing identifiers. It also automatically gathers and outputs extensive cross-reference information. Synopsis:

```
weave [option]... webfile[.web] [changefile[.ch]]
```

The output is to the basename of `webfile` extended with `tex`; for example, `weave /wherever/foo.web` creates `/foo.tex`. Weave applies `changefile` to `webfile` before writing the output; by default, there is no change file.

The program accepts the following option, as well as the standard `--verbose`, `--help` and `--version` (see Section 3.2 [Common options], page 7):

`-x` Omit the cross-reference information: the index, the list of WEB module names, and the table of contents (an empty CONTENTS.tex file will still be written when the Weave output file is processed by \TeX\ using the default `webmac.tex`, though).

Conventionally, WEB programmers should define the \TeX\ \texttt{title} macro at the beginning of the source file. Also, to get output of only changed modules, one can say `\let\maybe=\iffalse` (usually as the first change in the change file).

### 8.3 Pooltype: Display WEB pool files

Pooltype shows the so-called string number of each string in a WEB pool file (see Chapter 8 [WEB], page 37), as output by Tangle (see Section 8.1 [tangle invocation], page 37), including the first 256 strings corresponding to the possible input characters. Pooltype primarily serves as an example of WEB conventions to implementors of the \TeX\ system. Synopsis:

```
pooltype [option]... poolfile[.pool]
```

No path searching is done for `poolfile`. Output is to standard output.

The only options are `--help` and `--version` (see Section 3.2 [Common options], page 7).

As an example of the output, here is the (edited) output for `tex.pool`:

```
0: "^^@"
1: "^^A"
...
255: "^^ff"
256: "pool size"
...
1314: "Using character substitution: "
```
In Metafont and MetaPost, the first 256 characters are actually represented as single bytes (i.e., themselves), not in the ‘^^’ notation. Consider Pooltype as showing the results after conversion for output.
9 DVI utilities

\TeX\ outputs a file in DVI (DeVice Independent) format as a compact representation of the original document. DVI files can be translated to meet the requirements of a real physical device, such as PostScript printers (see Section “Introduction” in \texttt{Dvips}), PCL printers (see \texttt{dvilj(1)}), and X displays (see \texttt{xdvi(1)}). In fact, DVI translators are available for virtually all common devices: see \texttt{CTAN:/dviware} (for CTAN info, see Section “unixtex.ftp” in \texttt{Kpathsea}).

For the precise definition of the DVI file format, see (for example) the source file \texttt{web2c/dvitype.web}.

The DVI-processing programs in the Web2c distribution are not device drivers; they perform generic utility functions.

9.1 DVIcopy: Canonicalize virtual font references

DVIcopy reads a DVI file, expands any references to virtual fonts (see Section “Virtual fonts” in \texttt{Dvips}) to base fonts, and writes the resulting DVI file. Thus you can use virtual fonts even if your DVI processor does not support them, by passing the documents through DVIcopy first. Synopsis:

\begin{verbatim}
dvicopy [option]... [indvi[dvi] [outdvi[dvi]]]
\end{verbatim}

DVIcopy reads standard input if \texttt{indvi} is not specified, and writes standard output if \texttt{outdvi} is not specified.

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-magnification=integer’

Override existing magnification in \texttt{indvi} with \texttt{integer}; 1000 specifies no magnification. This is equivalent to setting \TeX’s \texttt{mag} parameter.

‘-max-pages=n’

Process \texttt{n} pages; default is one million.

‘-page-start=page-spec’

Start at the first page matching \texttt{page-spec}, which is one or more (signed) integers separated by periods, corresponding to \TeX’s \texttt{\count0...9} parameters at \texttt{\shipout} time; ‘*’ matches anything. Examples: ‘3’, ‘1.*.-4’.

9.2 DVItype: Plain text transliteration of DVI files

DVItype translates a DeVice Independent (DVI) file (as output by \TeX, for example) to a plain text file that humans can read. It also serves as a DVI-validating program, i.e., if DVItype can read a file, it’s correct. Synopsis:

\begin{verbatim}
dvitype [option]... dvifile[dvi]
\end{verbatim}

DVItype does not read any bitmap files, but it does read TFM files for fonts referenced in \texttt{dvifile}. The usual places are searched (see Section “Supported file formats” in \texttt{Kpathsea}). To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to ‘-1’ before running the program.
Output goes to standard output.

The program accepts the following options, as well as the standard ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-dpi=real’
Do pixel movement calculations at real pixels per inch; default 300.0.

‘-magnification=integer’
Override existing magnification in indvi with integer; 1000 specifies no magnification. This is equivalent to setting \TeX's \mag parameter.

‘-max-pages=n’
Process n pages; default is one million.

‘-output-level=n’
Verbosity level of output, from 0 to 4 (default 4):
• 0: Global document information only.
• 1: Most DVI commands included, and typeset characters summarized.
• 2: Character and movement commands explicitly included.
• 3: DVI stack and current position calculations included.
• 4: Same information as level 3, but DVIType does random positioning in the file, reading the DVI postamble first.

‘-page-start=page-spec’
Start at the first page matching page-spec, which is one or more (signed) integers separated by periods, corresponding to \TeX's \count0...9 parameters at \shipout time; ‘*’ matches anything. Examples: ‘1’, ‘5.*.-9’.

‘-show-opcodes’
Show numeric opcode values (in decimal) for DVI commands, in braces after the command name. This can help in debugging DVI utilities. We use decimal because in the DVI format documentation (in dvitype.web, among others) the opcodes are shown in decimal.

9.2.1 DVIType output example
As an example of the output from DVIType (see section above), here is its (abridged) translation of the story.dvi resulting from running the example in The \TeXbook, with ‘-output-level=4’ and ‘-show-opcodes’ on.

... 

Options selected:
Starting page = *
Maximum number of pages = 1000000
Output level = 4 (the works)
Resolution = 300.00000000 pixels per inch
numerator/denominator=25400000/473628672
magnification=1000; 0.00006334 pixels per DVI unit
' Tex output 1992.05.17:0844'
Postamble starts at byte 564.
maxv=43725786, maxh=30785863, maxstackdepth=3, totalpages=1
Font 33: cmsl10---loaded at size 655360 DVI units
Font 23: cmbx10---loaded at size 655360 DVI units
Font 0: cmr10---loaded at size 655360 DVI units

42: beginning of page 1
87: push {141}
level 0:(h=0,v=0,w=0,x=0,y=0,z=0, hh=0,vv=0)
88: down3 -917504 {159} v:=0-917504=-917504, vv:=−58
92: pop {142}
...
104: putrule {137} height 26214, width 30785863 (2x1950 pixels)
113: down3 5185936 {159} v:=655360+5185936=5841296, vv:=370
117: push {141}
level 1:(h=0,v=5841296,w=0,x=0,y=0,z=0, hh=0,vv=370)
118: right4 12265425 {146} h:=0+12265425=12265425, hh:=777
[ ]
123: fntdef1 23 {243}: cmbx10
145: fnnum23 {194} current font is cmbx10
146: setchar65 h:=12265425+569796=12835221, hh:=813
147: w3 251220 {150} h:=12835221+251220=13086441, hh:=829
151: setchar83 h:=13086441+418700=13505141, hh:=856
...
164: setchar82 h:=17448202+565245=18013447, hh:=1142
165: x0 -62805 {152} h:=18013447−62805=17950642, hh:=1138
166: setchar89 h:=17950642+569796=18520438, hh:=1174
[A SHORT STORY]
167: pop {142}
level 1:(h=0,v=5841296,w=0,x=0,y=0,z=0, hh=0,vv=370)
...
550: pop {142}
level 0:(h=0,v=42152922,w=0,x=0,y=0,z=0, hh=0,vv=2670)
551: down3 1572864 {159} v:=42152922+1572864=43725786, vv:=2770
555: push {141}
level 0:(h=0,v=43725786,w=0,x=0,y=0,z=0, hh=0,vv=2770)
556: right4 15229091 {146} h:=0+15229091=15229091, hh:=965
561: setchar49 h:=15229091+327681=15556772, hh:=986
[ 1]
562: pop {142}
level 0:(h=0,v=43725786,w=0,x=0,y=0,z=0, hh=0,vv=2770)
563: eop {140}

Explanation:

- The DVI type options are recorded at the beginning, followed by global information about the document, including fonts used.
- Each DVI command is preceded by its byte position in the file (‘42:’, ‘87:’, ...),
and (because of the ‘-show-opcodes’) followed by its decimal opcode value in braces
(‘141’, ‘142’, . . .).

• The ‘level’ lines record information about the DVI stack; ‘h’ and ‘v’ define the current
position in DVI units, while ‘hh’ and ‘vv’ are the same in pixels.

• Text sequences are summarized in brackets, as in ‘[A SHORT STORY]’ and the ‘[ 1]’.
10 Font utilities

The Web2c programs described here convert between various \TeX-related font formats; the first section below briefly describes the formats. GFtoPK is the only one that is routinely used, as Metafont outputs GF format, but it’s most efficient for device drivers to use PK.

The precise definitions of the PK, GF, TFM, PL, VF, and VPL formats mentioned below are in the source files that read them; pktype.web, gftype.web, tftopl.web, etc.

10.1 Font file formats

(For another perspective on this, see Section “Font concepts” in Dvips).

Font files come in several varieties, with suffixes like:

.tfm .pk .gf .pxl (obsolete) .pl .mf .vf .vpl

Each represents a file format.

A TFM (\TeX font metric) file is a compact binary file that contains information about each character in a font, about combinations of characters within that font, and about the font as a whole. The font metric information contained in TFM files is device-independent units is used by \TeX to do typesetting. Unlike the bitmap (raster) fonts described below, TFM font files contain no information about the shapes of characters. They describe rectangular areas and combinations thereof, but not what will eventually be printed in those areas.

Since \TeX does scaling calculations, one TFM file serves for all magnifications of a given typeface. On the other hand, the best printed results are obtained when magnified (or reduced fonts) are not produced geometrically (as done by PostScript, for example) but rather optically, with each size a separate design (as done with Computer Modern and the EC fonts, for example); then a separate TFM file is needed for each size.

At any rate, \TeX produces a DVI (DeVice Independent) file from your source document. In order to print DVI files on real devices, you need font files defining digitized character shapes and other data. Then previewers and printer-driver programs can translate your DVI files into something usable by your monitor or printer. Bitmap fonts come with suffixes such as ‘.600pk’ or ‘.600gf’ or ‘.3000pxl’, where the ‘600’ is the horizontal dots-per-inch resolution at which the font was produced, and the ‘pk’ or ‘gf’ or ‘pxl’ indicates the font format. Outline fonts in PostScript Type 1 format have suffixes such as ‘.pfa’ or ‘.pfb’.

Fonts in pk (packed) format are in the tightly packed raster format that is pretty much the standard today. They take up less space than fonts in the gf (generic font) format that Metafont generates, and far less space than fonts in pxl format. Fonts in pxl format take up gross amounts of disk space and permit only 128 characters. They are obsolete.

Font files with the ‘.pl’ (property list) suffix are the plain text (human-readable) analog of the binary ‘.tfm’ files. The TFtoPL and PLtoTF programs convert between the two formats (see Section 10.6 [tftopl invocation], page 49, and Section 10.7 [pltotf invocation], page 51).

Font files with the ‘.mf’ suffix are in Metafont source format. These are the files used by Metafont to generate rastered fonts for specific typefaces at specific magnifications for the specific resolution and type of mapping used by your device.
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The suffix `.vf' identifies “virtual font” files, for which `.vpl' is the human-readable analog. See
See Section 10.8 [vftovp invocation], page 51, and Section 10.9 [vptofvf invocation], page 52. For further discussion of virtual fonts, see CTAN:/doc/virtual-fonts.knuth, CTAN:/help/virtualfonts.txt, and Section “Virtual fonts” in Dvips.

(This section is based on documentation in the original Unix TEX distribution by Pierre
MacKay and Elizabeth Tachikawa.)

10.2 GFtoPK: Generic to packed font conversion

GFtoPK converts a generic font (GF) file output by, for example, Metafont (see Section 5.1 [mf invocation], page 25) to a packed font (PK) file. PK files are considerably smaller than the corresponding gf files, so they are generally the bitmap font format of choice. Some DVI-processing programs, notably Dvips, only support PK files and not GF files. Synopsis:

gftopk [option]... gfname.dpi[gf] [pkfile]

The font gfname is searched for in the usual places (see Section “Glyph lookup” in Kpathsea). To see all the relevant paths, set the environment variable KPATHSEA_DEBUG to ‘-1’ before running the program.

The suffix ‘gf’ is supplied if not already present. This suffix is not an extension; no ‘.’ precedes it: for instance, cmr10.600gf.

If pkfile is not specified, the output is written to the basename of ‘gfname.dpipk’, e.g.,
gftopk /wherever/cmr10.600gf’ creates ./cmr10.600pk.

The only options are ‘--verbose’, ‘--help’, and ‘--version’ (see Section 3.2 [Common
options], page 7).

10.3 PKtoGF: Packed to generic font conversion

PKtoGF converts a packed font (PK) file to a generic font (GF) file. Since PK format is
much more compact than GF format, the most likely reason to do this is to run GFType (see Section 10.5 [gftype invocation], page 47) on the result, so you can see the bitmap images.

Also, a few old utility programs do not support PK format. Synopsis:

pktogf [option]... pkname.dpi[pk] [gffile]

The font pkname is searched for in the usual places (see Section “Glyph lookup” in Kpathsea). To see all the relevant paths, set the environment variable KPATHSEA_DEBUG to ‘-1’ before running the program.

The suffix ‘pk’ is supplied if not already present. This suffix is not an extension; no ‘.’
precedes it: for instance, cmr10.600pk.

If gffile is not specified, the output is written to the basename of ‘pkname.dpigf’, e.g.,
pktogf /wherever/cmr10.600pk’ creates ./cmr10.600gf.

The only options are ‘--verbose’, ‘--help’, and ‘--version’ (see Section 3.2 [Common
options], page 7).

10.4 PKtype: Plain text transliteration of packed fonts

PKType translates a packed font (PK) bitmap file (as output by GFtoPK, for example) to
a plain text file that humans can read. It also serves as a PK-validating program, i.e., if
PKType can read a file, it’s correct. Synopsis:
pktype pkname.dpi[pk]

The font pkname is searched for in the usual places (see Section “Glyph lookup” in Kpathsea). To see all the relevant paths, set the environment variable KPATHSEA_DEBUG to `-1` before running the program.

The suffix ‘pk’ is supplied if not already present. This suffix is not an extension; no ‘.’ precedes it: for instance, cmr10.600pk.

The translation is written to standard output.

The only options are ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7).

As an example of the output, here is the (abridged) translation of the letter ‘K’ in ‘cmr10’, as rendered at 600dpi with the mode ‘ljfour’ from modes.mf (available from ftp://ftp.tug.org/tex/modes.mf).

955: Flag byte = 184 Character = 75 Packet length = 174
Dynamic packing variable = 11
TFM width = 815562 dx = 4259840
Height = 57 Width = 57 X-offset = -3 Y-offset = 56
[2]23(16)17(8)9(25)11(13)7(27)7(16)7(28)4(18)7(28)2(20)7(27)...
   ...
   (14)9(24)12(5)[2]23(13)21

Explanation:

‘955’ The byte position in the file where this character starts.

‘Flag byte’

‘Dynamic packing variable’ Related to the packing for this character; see the source code.

‘Character’ The character code, in decimal.

‘Packet length’ The total length of this character definition, in bytes.

‘TFM width’ The device-independent (TFM) width of this character. It is 2^24 times the ratio of the true width to the font’s design size.

‘dx’ The device-dependent width, in scaled pixels, i.e., units of horizontal pixels times 2^16.

‘Height’ ‘Width’ The bitmap height and width, in pixels.

‘X-offset’ ‘Y-offset’ Horizontal and vertical offset from the upper left pixel to the reference (origin) pixel for this character, in pixels (right and down are positive). The reference pixel is the pixel that occupies the unit square in Metafont; the Metafont reference point is the lower left hand corner of this pixel. Put another way, the x-offset is the negative of the left side bearing; the right side bearing is the horizontal escapement minus the bitmap width plus the x-offset.
Finally, run lengths of black pixels alternate with parenthesized run lengths of white pixels, and brackets indicate a repeated row.

10.5 GFtype: Plain text transliteration of generic fonts

GFtype translates a generic font (GF) bitmap file (as output by Metafont, for example) to a plain text file that humans can read. It also serves as a GF-validating program, i.e., if GFtype can read a file, it’s correct. Synopsis:

```
gftype [option]... gfname.dpi[gf]
```

The font `gfname` is searched for in the usual places (see Section “Glyph lookup” in `Kpathsea`). To see all the relevant paths, set the environment variable `KPATHSEA_DEBUG` to `-1` before running the program.

The suffix `gf` is supplied if not already present. This suffix is not an extension; no `.` precedes it: for instance, `cmr10.600gf`.

The translation is written to standard output.

The program accepts the following options, as well as the standard `-help` and `-version` (see Section 3.2 [Common options], page 7):

`-images` Show the characters’ bitmaps using asterisks and spaces.

`-mnemonics` Translate all commands in the GF file.

As an example of the output, here is the (abridged) translation of the letter ‘K’ in ‘cmr10’, as rendered at 600 dpi with the mode ‘ljfour’ from `modes.mf` (available from `ftp://ftp.tug.org/tex/modes.mf`), with both `-mnemonics` and `-images` enabled.

GFtype outputs the information about a character in two places: a main definition and a one-line summary at the end. We show both. Here is the main definition:

```
2033: beginning of char 75: 3<=m<=60 0<=n<=56
   (initially n=56) paint (0)24(12)20
2043: newrow 0 (n=55) paint 24(12)20
2047: newrow 0 (n=54) paint 24(12)20
2051: newrow 0 (n=53) paint 24(12)20
2055: newrow 7 (n=52) paint 10(21)13
2059: newrow 8 (n=51) paint 8(23)9
...
2249: newrow 8 (n=5) paint 8(23)11
2253: newrow 7 (n=4) paint 10(22)12
2257: newrow 0 (n=3) paint 24(11)22
2261: newrow 0 (n=2) paint 24(11)22
2265: newrow 0 (n=1) paint 24(11)22
2269: newrow 0 (n=0) paint 24(11)22
2273: eoc
```
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Explanation:

'2033'
'2043'
'...' The byte position in the file where each GF command starts.

'beginning of char 75'
The character code, in decimal.

'3<=m<=60 0<=n<=56'
The character's bitmap lies between 3 and 60 (inclusive) horizontally, and between 0 and 56 (inclusive) vertically. \((m\) is a column position and \(n\) is a row position.) Thus, 3 is the left side bearing. The right side bearing is the horizontal escapement (given below) minus the maximum \(m\).

'(initially \(n=56\)) paint (0)24(12)20'
The first row of pixels: 0 white pixels, 24 black pixels, 12 white pixels, etc.

'newrow 0 (n=55) paint 24(12)20'
The second row of pixels, with zero leading white pixels on the row.

'eoc' The end of the main character definition.

Here is the GF postamble information that GFtype outputs at the end:

**Character 75: dx 4259840 (65), width 815562 (64.57289), loc 2033**

Explanation:

'dx' The device-dependent width, in scaled pixels, i.e., units of horizontal pixels times \(2^{16}\). The ‘(65)’ is simply the same number rounded. If the vertical escapement is nonzero, it would appear here as a ‘dy’ value.

'width' The device-independent (TFM) width of this character. It is \(2^{24}\) times the ratio of the true width to the font’s design size. The ‘64.57289’ is the same number converted to pixels.

'loc' The byte position in the file where this character starts.
10.6 TFtoPL: T\TeX font metric to property list conversion

TFtoPL translates a T\TeX font metric (TFM, see Section “Metric files” in Dvips) file (as output by Metafont, for example) to property list format (a list of parenthesized items describing the font) that humans can edit or read. This program is mostly used by people debugging T\TeX implementations, writing font utilities, etc. Synopsis:

\texttt{tftopl [option]... tfmname\.tfm [plfile\.pl]}

The font \texttt{tfmname} (extended with `.tfm` if necessary) is searched for in the usual places (see Section “Supported file formats” in Kpathsea). To see all the relevant paths, set the environment variable \texttt{KPATHSEA_DEBUG} to `-1` before running the program.

If \texttt{plfile} (which is extended with `.pl` if necessary) is not specified, the property list file is written to standard output. The property list file can be converted back to TFM format by the companion program TFtoPL (see the next section).

The program accepts the following option, as well as the standard `-verbose`, `-help` and `-version` (see Section 3.2 [Common options], page 7):

`-charcode-format=type`

Output character codes in the PL file according to \texttt{type}: either `octal` or `ascii`. Default is `ascii` for letters and digits, octal for all other characters. Exception: if the font’s coding scheme starts with `\TeX math sy` or `\TeX math ex`, all character codes are output in octal.

In `ascii` format, character codes that correspond to graphic characters, except for left and right parentheses, are output as a `C` followed by the single character: `C K`, for example. In octal format, character codes are output as the letter `O` followed by octal digits, as in `O 113` for `K`.

`octal` format is useful for symbol and other non-alphabetic fonts, where using ASCII characters for the character codes is merely confusing.

As an example of the output, here is the (abridged) property list translation of \texttt{cmr10.tfm}:

\begin{verbatim}
(FAMILY CMR)
(FACE O 352)
(CODINGSCHEME TEX TEXT)
(DESIGNIZE R 10.0)
(COMMENT DESIGNSIZE IS IN POINTS)
(COMMENT OTHER SIZES ARE MULTIPLES OF DESIGNSIZE)
(CHECKSUM O 11374260171)
(FONTDIMEN
  (SLANT R 0.0)
  (SPACE R 0.333334)
  (STRETCH R 0.166667)
  (SHRINK R 0.111112)
  (XHEIGHT R 0.430555)
  (QUAD R 1.000003)
  (EXTRASPACE R 0.111112)
 )
(LIGTABLE
\end{verbatim}
As you can see, the general format is a list of parenthesized properties, nested where necessary.

- The first few items (FAMILY, FACE, and so on) are the so-called headerbyte information from Metafont, giving general information about the font.
- The FONTDIMEN property defines the \fontdimen values.
- The LIGTABLE property defines the ligature and kerning table. LIG properties define ligatures: in the example above, an ‘f’ (in the ‘LABEL’) followed by an ‘i’ is a ligature, i.e., a typesetting program like \TeX replaces those two consecutive characters by the character at position octal ‘014 in the current font—presumably the ‘fi’ ligature. KRN properties define kerns: if an ‘f’ is followed by character octal ‘047 (an apostrophe), \TeX inserts a small amount of space between them: 0.077779 times the design size the font was loaded at (about three-quarters of a printer’s point by default in this case, or .001 inches).
- The CHARACTER property defines the dimensions of a character: its width, height, depth, and italic correction, also in design-size units, as explained in the previous item. For our example ‘f’, the depth is zero, so that property is omitted. TFtoPL also inserts any kerns and ligatures for this character as a comment.
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10.7 PLtoTF: Property list to TeX font metric conversion

PLtoTF translates a property list file (as output by TFtoPL, for example) to TeX font metric (TFM, see Section “Metric files” in Dvips) format. It’s much easier for both programs and humans to create the (plain text) property list files and let PLtoTF take care of creating the binary TFM equivalent than to output TFM files directly. Synopsis:

```bash
pltotf [option]... plfile [.pl] [tfmfile [.tfm]]
```

If `tfmfile` (extended with ‘.tfm’ if necessary) is not specified, the TFM file is written to the basename of ‘plfile.tfm’, e.g., ‘pltotf /wherever/cmr10.pl’ creates ‘/cmr10.tfm’. (Since TFM files are binary, writing to standard output by default is undesirable.)

The only options are ‘-verbose’, ‘-help’, and ‘-version’ (see Section 3.2 [Common options], page 7).

For an example of property list format, see the previous section.

10.8 VFtoVP: Virtual font to virtual property lists

VFtoVP translates a virtual font metric (VF, see Section “Virtual fonts” in Dvips) file and its accompanying TeX font metric (TFM, see Section “Metric files” in Dvips) file (as output by VPtoVF, for example) to virtual property list format (a list of parenthesized items describing the virtual font) that humans can edit or read. This program is mostly used by people debugging virtual font utilities. Synopsis:

```bash
vftovp [option]... vfname [.vf] [tfmname [.tfm] [vplfile [.vpl]]]
```

The fonts `vfname` and `tfmname` (extended with ‘.vf’ and ‘.tfm’ if necessary) are searched for in the usual places (see Section “Supported file formats” in Kpathsea). To see all the relevant paths, set the environment variable `KPATHSEA_DEBUG` to ‘-1’ before running the program. If `tfmname` is not specified, `vfname` (without a trailing ‘.vf’) is used.

If `vplfile` (extended with ‘.vpl’ if necessary) is not specified, the property list file is written to standard output. The property list file can be converted back to VF and TFM format by the companion program VFtoVP (see the next section).

The program accepts the following option, as well as the standard ‘-verbose’, ‘-help’ and ‘-version’ (see Section 3.2 [Common options], page 7):

‘-charcode-format=type’

Output character codes in the PL file according to type: either ‘octal’ or ‘ascii’. Default is ‘ascii’ for letters and digits, octal for all other characters. Exception: if the font’s coding scheme starts with ‘TeX math sy’ or ‘TeX math ex’, all character codes are output in octal.

In ‘ascii’ format, character codes that correspond to graphic characters, except for left and right parentheses, are output as a ‘C’ followed by the single character: ‘C K’, for example. In octal format, character codes are output as the letter ‘0’ followed by octal digits, as in ‘0 113’ for ‘k’.

‘octal’ format is useful for symbol and other non-alphabetic fonts, where using ASCII characters for the character codes is merely confusing.
10.9 VPtoVF: Virtual property lists to virtual font

VPtoVF translates a virtual property list file (as output by VFtoVP, for example) to virtual font (VF, see Section “Virtual fonts” in Dvips) and \TeX font metric (TFM, see Section “Metric files” in Dvips) files. It’s much easier for both programs and humans to create the (plain text) property list files and let VPtoVF take care of creating the binary VF and TFM equivalents than to output them directly. Synopsis:

```
vptovf [option]... vplfile[vpl] [vffile[vf] [tfmfile[tfm]]]
```

If `vffile` (extended with `.vf` if necessary) is not specified, the VF output is written to the basename of `vplfile.vf`; similarly for `tfmfile`. For example, `vptovf /wherever/ptmr.vpl` creates `/ptmr.vf` and `/ptmr.tfm`.

The only options are `-verbose`, `-help`, and `-version` (see Section 3.2 [Common options], page 7).

10.10 Font utilities available elsewhere

The Web2c complement of font utilities merely implements a few basic conversions. Many other more sophisticated font utilities exist; most are in CTAN:/fonts/utilities (for CTAN info, see Section “unixtex.ftp” in Kpathsea). Here are some of the most commonly-requested items:

- AFM (Adobe font metric) to TFM conversion: see Section “Invoking afm2tfm” in Dvips, and CTAN:/fonts/utilities/afmtopl.
- Creating fonts using MetaPost: MetaType1. ftp://bop.eps.gda.pl/pub/metatype1. This is used to create the excellent Latin Modern font family (CTAN:/fonts/lm), which extends Computer Modern to a vast repertoire of scripts.
- Editing of bitmap fonts: Xbfe from the GNU font utilities mentioned below; the X BDF-editing programs available from ftp://ftp.x.org/R5contrib/xfed.tar.Z and ftp://ftp.x.org/R5contrib/xfedor.tar.Z; and finally, if your fonts have only 128 characters, you can use the old gftopxl, pxtoch, and chtopx programs from ftp://ftp.tug.org/tex/web.
- Editing of outline fonts: FontForge, fontforge.sourceforge.net. This is a very elaborate program with support for many outline formats (Type 1, OpenType, TrueType, ...), and many advanced font editing features.
- PK bitmaps from PostScript outline fonts: gsftopk from the ‘xdvi’ distribution. Alternatively, ps2pk, from CTAN:/fonts/utilities/ps2pk.
- PostScript Type 1 font format conversion (i.e., between PFA and PFB formats): http://www.lcdf.org/type.
- Scanned image conversion: the (aging) GNU font utilities convert type specimen images to Metafont, PostScript, etc.: http://www.gnu.org/software/fontutils/.
- Virtual font creation: CTAN:/fonts/utilities/fontinst.
Appendix A Legalisms

In general, each file has its own copyright notice stating the copying permissions for that file. Following is a summary.

The Web2c system itself and most of the original WEB source files are public domain.

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Finally, the Kpathsea library is covered by the GNU Lesser General Public License (see Section “Introduction” in Kpathsea). Therefore, the binaries resulting from a standard Web2c compilation are also covered by the LGPL; so if you (re)distribute the binaries, you must also (offer to) distribute the complete source that went into those binaries. See the file LGPL for complete details on the LGPL.

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Appendix B References

1. Kpathsea: See Kpathsea.
2. Dvips and Afm2tfm: See Dvips.
3. The T\TeX Users Group: \url{http://www.tug.org}. For an introduction to the T\TeX system, see \url{http://tug.org/begin.html}.
4. TUGboat: \url{http://tug.org/TUGboat}.
5. T\TeX and computer typesetting in general: \url{ftp://ftp.math.utah.edu/pub/tex/bib/texbook1.bib}.
6. For a bibliography of formal articles and technical reports on the T\TeX project, see the books \textit{T\TeX: The Program} or \textit{Metafont: The Program} cited below.


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